US009137833B2

(12) United States Patent
Naoe et al.

(10) Patent No.: US 9,137,833 B2
(45) Date of Patent: Sep. 15, 2015

# (54) MOBILE COMMUNICATION SYSTEM

(75) Inventors: **Hirokazu Naoe**, Osaka (JP); **Masafumi Aramoto**, Osaka (JP)

(73) Assignee: **SHARP KABUSHIKI KAISHA**, Osaka (JP)

( * ) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 346 days.

(21) Appl. No.: **13/259,071**

(22) PCT Filed: **Mar. 26, 2010**

(86) PCT No.: **PCT/JP2010/002185**

§ 371 (c)(1), (2), (4) Date: **Sep. 22, 2011**

(87) PCT Pub. No.: **WO2010/109902**

PCT Pub. Date: **Sep. 30, 2010**

(65) **Prior Publication Data**

US 2012/0020318 A1 Jan. 26, 2012

(30) **Foreign Application Priority Data**

Mar. 27, 2009 (JP) ................................ P2009-079962

(51) **Int. Cl.**
***H04W 72/04*** (2009.01)
***H04W 76/02*** (2009.01)
(Continued)

(52) **U.S. Cl.**
CPC .............. ***H04W 76/022*** (2013.01); ***H04W 8/26*** (2013.01); *H04W 40/24* (2013.01); *H04W 84/18* (2013.01)

(58) **Field of Classification Search**
CPC ..... H04W 76/022; H04W 8/26; H04W 84/18; H04W 40/24
USPC .......... 370/225, 328, 338, 400, 329; 445/436; 380/278; 455/436
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

6,763,012 B1 * 7/2004 Lord et al. .................... 370/338
8,566,455 B1 * 10/2013 Zhao et al. .................... 709/227
(Continued)

FOREIGN PATENT DOCUMENTS

JP 2004-507905 A 3/2004
JP 2006-261902 A 9/2006
(Continued)

OTHER PUBLICATIONS

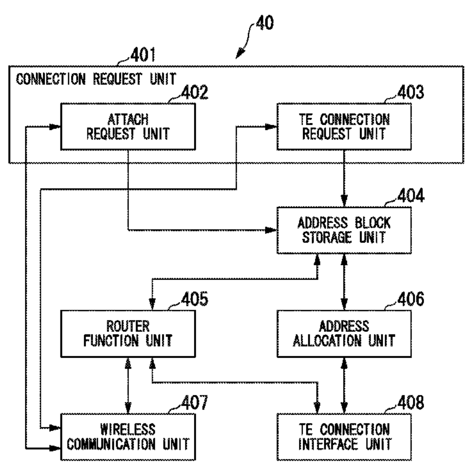
3GPP, "Technical Specification Group Core Network; Packet Domain; Mobile Station (MS) supporting Packet Switched Services (Release 8)", 3GPP TS 27.060 V8.0.0 (Dec. 2008), pp. 1-33.
(Continued)

*Primary Examiner* — Kwang B Yao
*Assistant Examiner* — Syed M Bokhari
(74) *Attorney, Agent, or Firm* — Birch, Stewart, Kolasch & Birch, LLP

## (57) ABSTRACT

A core network includes a PDN connection holding unit that associates and stores information regarding PDN connection with information indicating an address block configured as a set of a plurality of addresses identifying a plurality of the information terminal devices. Therefore, it is possible to suppress an increase in the processing load and a limitation of providable services, even in the case in which an ad-hoc network is formed between a mobile terminal device and a plurality of terminal equipments and a PDN connection is made by the terminal equipments using the mobile terminal device as an MT.

**14 Claims, 17 Drawing Sheets**



(51) **Int. Cl.**

| | |
|---|---|
| ***H04W 8/26*** | (2009.01) |
| *H04W 40/24* | (2009.01) |
| *H04W 84/18* | (2009.01) |

(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | | |
|---|---|---|---|---|
| 2002/0145993 | A1* | 10/2002 | Chowdhury et al. | 370/338 |
| 2002/0172207 | A1* | 11/2002 | Saito et al. | 370/400 |
| 2003/0081578 | A1* | 5/2003 | White et al. | 370/338 |
| 2004/0184465 | A1 | 9/2004 | Lee et al. | |
| 2006/0171387 | A1 | 8/2006 | Kang et al. | |
| 2006/0239266 | A1 | 10/2006 | Babbar et al. | |
| 2007/0186100 | A1 | 8/2007 | Wakameda | |
| 2007/0249349 | A1* | 10/2007 | Park | 455/436 |
| 2007/0291670 | A1 | 12/2007 | Pettersson et al. | |
| 2010/0008507 | A1* | 1/2010 | Galante et al. | 380/278 |
| 2010/0122824 | A1* | 5/2010 | Aamodt | 169/16 |
| 2010/0199332 | A1 | 8/2010 | Bachmann et al. | |
| 2011/0122824 | A1* | 5/2011 | Muhanna et al. | 370/328 |
| 2013/0010645 | A1* | 1/2013 | Yu | 370/255 |

FOREIGN PATENT DOCUMENTS

| | | | |
|---|---|---|---|
| JP | 2006-520548 | A | 9/2006 |
| JP | 2007-208855 | A | 8/2007 |
| JP | 2008-511222 | A | 4/2008 |
| JP | 2008-538690 | A | 10/2008 |
| JP | 2010-530680 | A | 9/2010 |
| KR | 10-2004-0069878 | A | 8/2004 |
| WO | WO 00/76249 | A1 | 12/2000 |
| WO | WO 03/075517 | A2 | 9/2003 |
| WO | WO 2004/084492 | A1 | 9/2004 |
| WO | WO 2006/116190 | A2 | 11/2006 |
| WO | WO 2008/155066 | A2 | 12/2008 |

OTHER PUBLICATIONS

3GPP, "Technical Specification Group Services and System Aspects; General Packet Radio Service (GPRS) enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) access (Release 8)", 3GPP TS 23.401 V8.5.0 (Mar. 2009), pp. 1-222.

International Search Report, dated Jun. 29, 2010 in PCT/JP2010/002185.

W. Choi, et al., "Designing a Novel Unlicensed Nomadic Access Relay Station in IEEE 802.16-based Wireless Access Networks", IEEE VTS Vehicular Technology Conference Proceedings, IEEE, US, Apr. 1, 2007, pp. 2961-2965.

* cited by examiner

FIG. 1

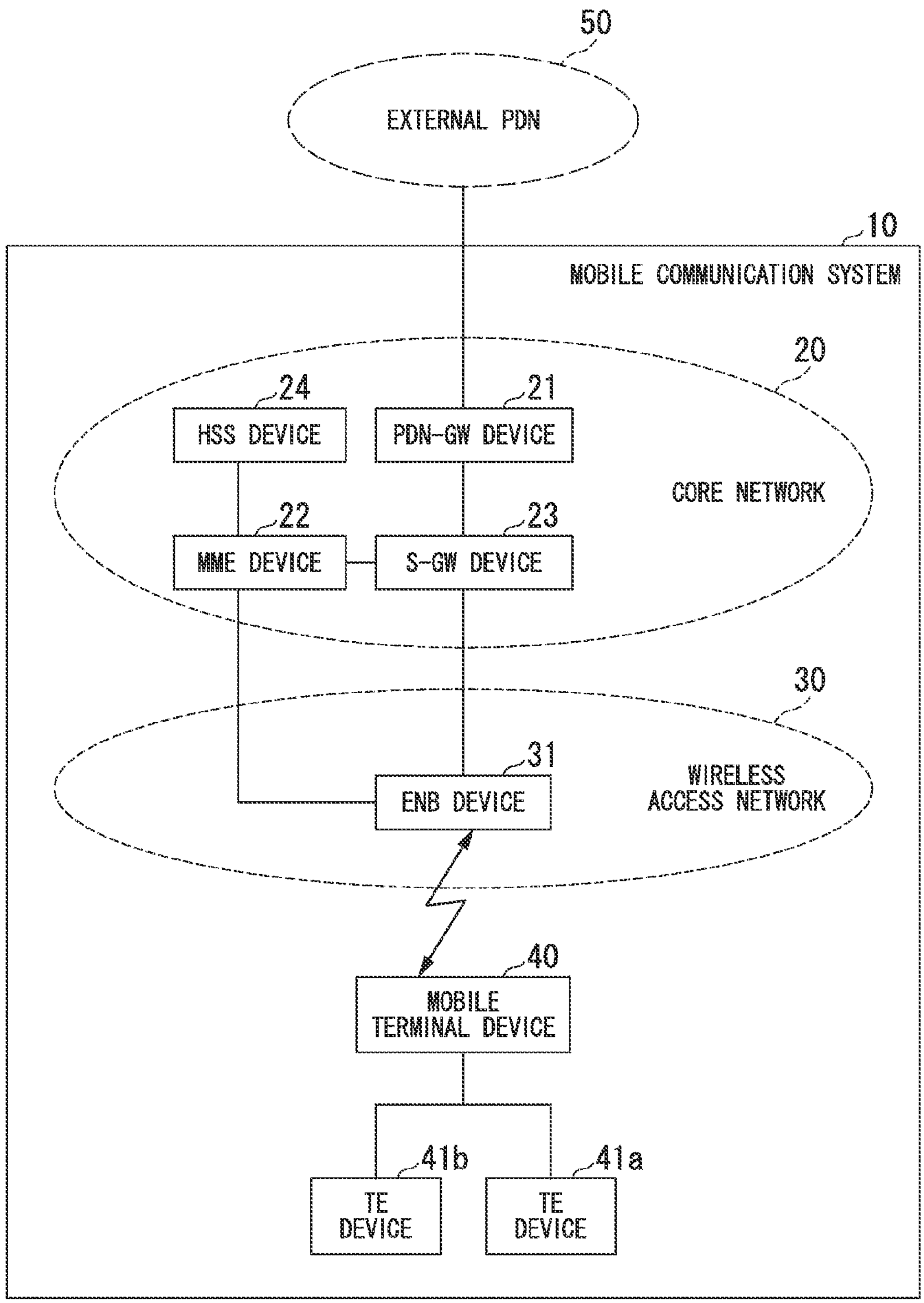

50
EXTERNAL PDN
10
MOBILE COMMUNICATION SYSTEM
20
24
HSS DEVICE
21
PDN-GW DEVICE
CORE NETWORK
22
MME DEVICE
23
S-GW DEVICE
30
31
ENB DEVICE
WIRELESS
ACCESS NETWORK
40
MOBILE
TERMINAL DEVICE
41b
TE
DEVICE
41a
TE
DEVICE

FIG. 2

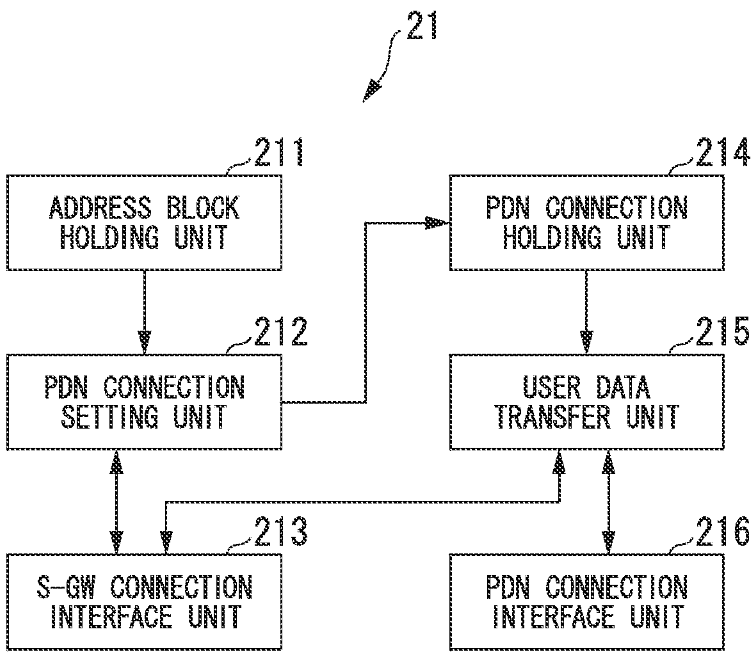

21
211
ADDRESS BLOCK HOLDING UNIT
212
PDN CONNECTION SETTING UNIT
213
S-GW CONNECTION INTERFACE UNIT
214
PDN CONNECTION HOLDING UNIT
215
USER DATA TRANSFER UNIT
216
PDN CONNECTION INTERFACE UNIT

FIG. 3

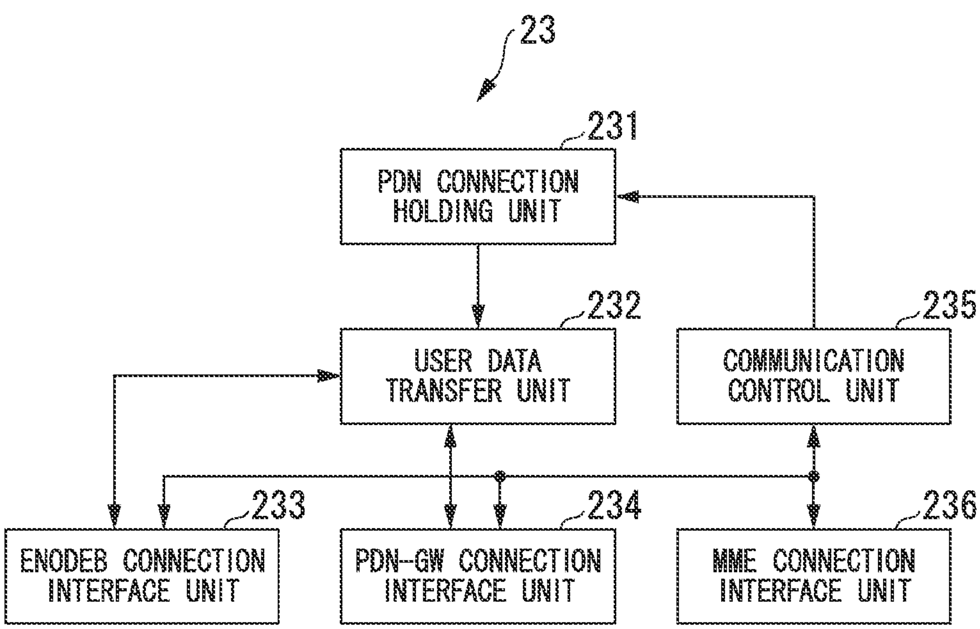

23
231
PDN CONNECTION HOLDING UNIT
232
USER DATA TRANSFER UNIT
235
COMMUNICATION CONTROL UNIT
233
ENODEB CONNECTION INTERFACE UNIT
234
PDN-GW CONNECTION INTERFACE UNIT
236
MME CONNECTION INTERFACE UNIT

FIG. 4

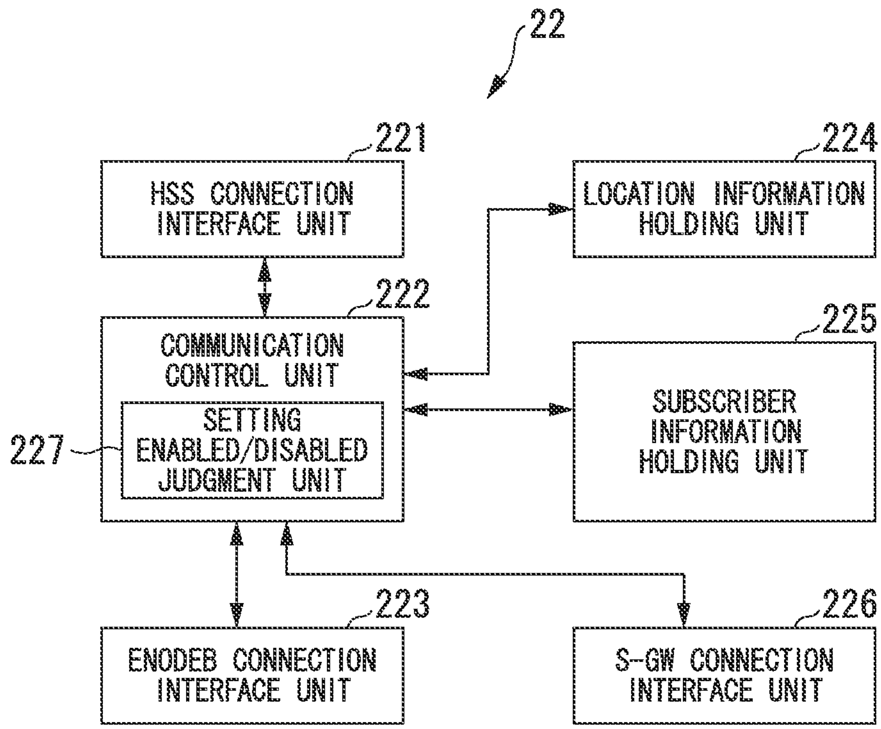

22
221
HSS CONNECTION INTERFACE UNIT
224
LOCATION INFORMATION HOLDING UNIT
222
COMMUNICATION CONTROL UNIT
SETTING ENABLED/DISABLED JUDGMENT UNIT
227
225
SUBSCRIBER INFORMATION HOLDING UNIT
223
ENODEB CONNECTION INTERFACE UNIT
226
S-GW CONNECTION INTERFACE UNIT

FIG. 5

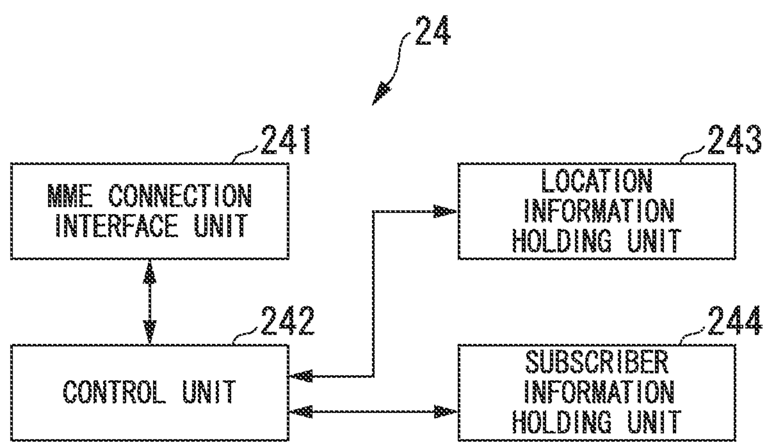
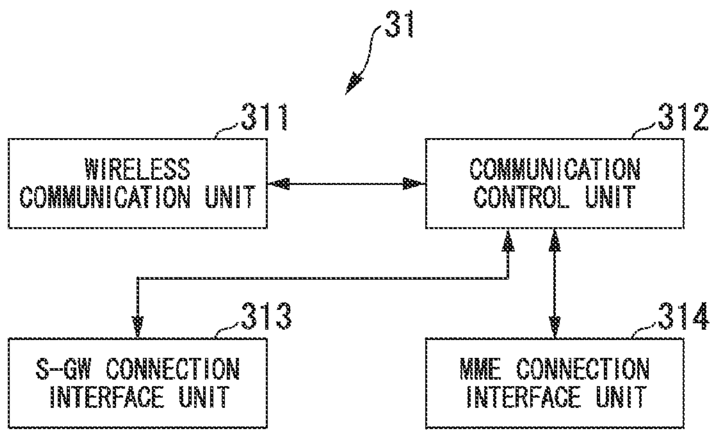
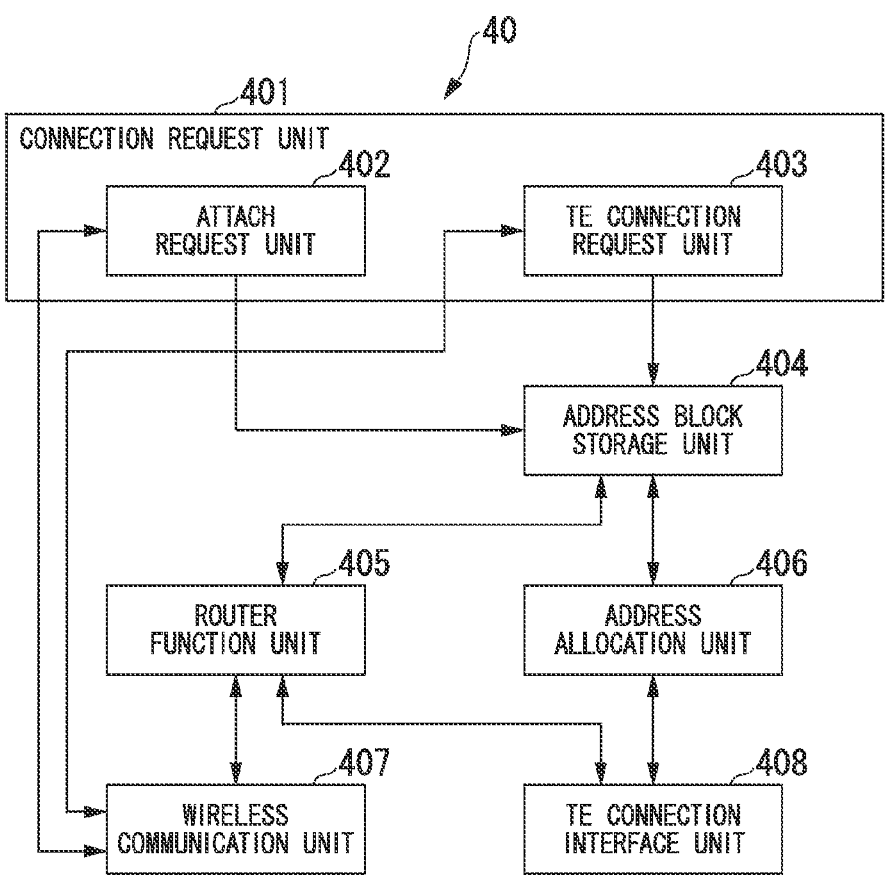

24
241
MME CONNECTION INTERFACE UNIT
243
LOCATION INFORMATION HOLDING UNIT
242
CONTROL UNIT
244
SUBSCRIBER INFORMATION HOLDING UNIT

FIG. 6



31
311
WIRELESS COMMUNICATION UNIT
312
COMMUNICATION CONTROL UNIT
313
S-GW CONNECTION INTERFACE UNIT
314
MME CONNECTION INTERFACE UNIT


FIG. 7



40
401
CONNECTION REQUEST UNIT
402
ATTACH REQUEST UNIT
403
TE CONNECTION REQUEST UNIT
404
ADDRESS BLOCK STORAGE UNIT
405
ROUTER FUNCTION UNIT
406
ADDRESS ALLOCATION UNIT
407
WIRELESS COMMUNICATION UNIT
408
TE CONNECTION INTERFACE UNIT

FIG. 8

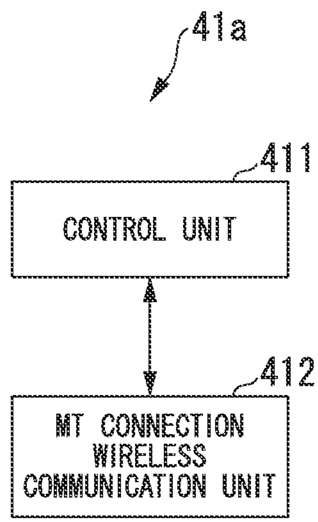

41a
411
CONTROL UNIT
412
MT CONNECTION
WIRELESS
COMMUNICATION UNIT

FIG. 9

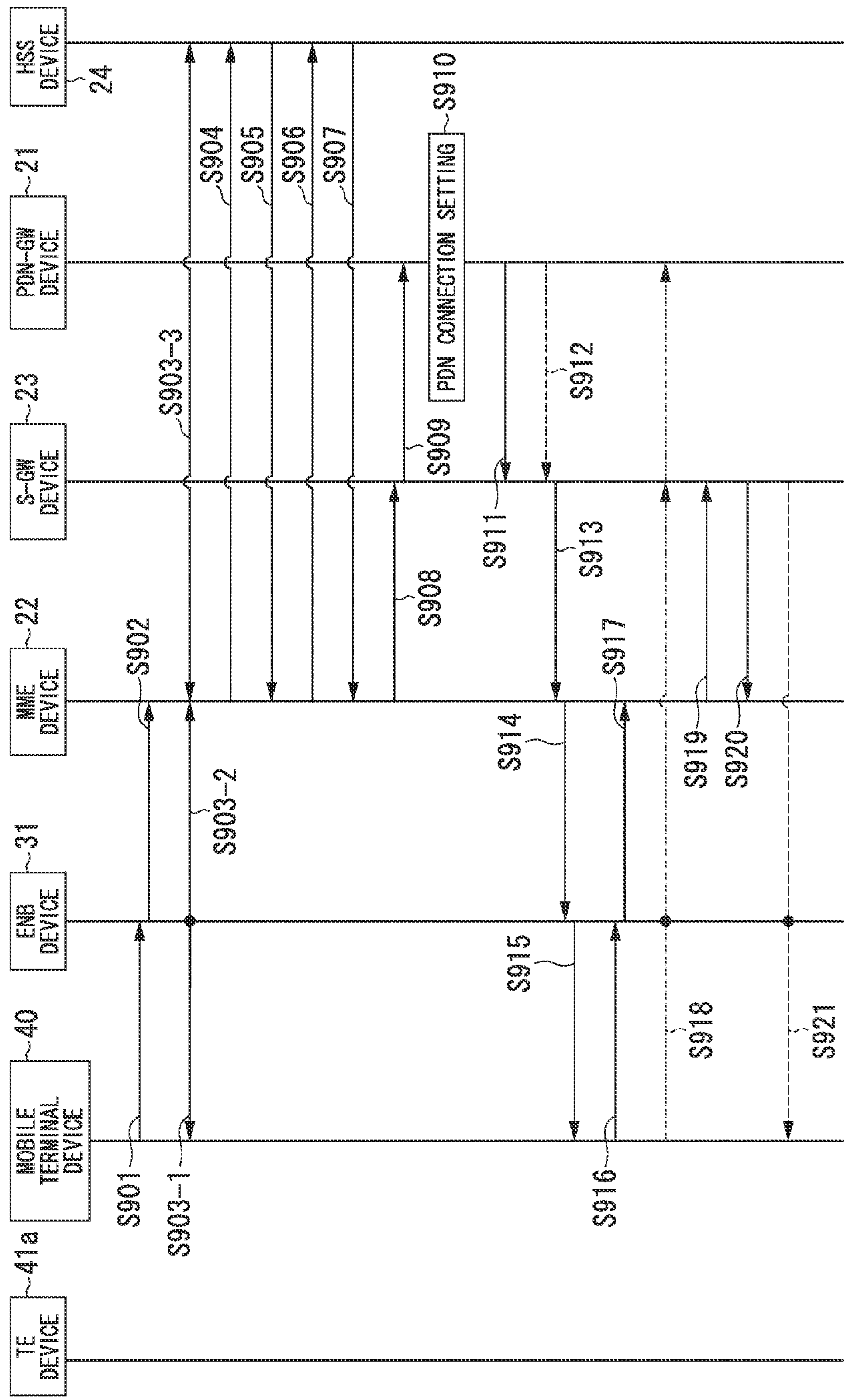

TE DEVICE
41a
MOBILE TERMINAL DEVICE
40
ENB DEVICE
31
MME DEVICE
22
S-GW DEVICE
23
PDN-GW DEVICE
21
HSS DEVICE
24
S901
S902
S903-1
S903-2
S903-3
S904
S905
S906
S907
S908
S909
PDN CONNECTION SETTING
S910
S911
S912
S913
S914
S915
S916
S917
S918
S919
S920
S921

FIG. 10

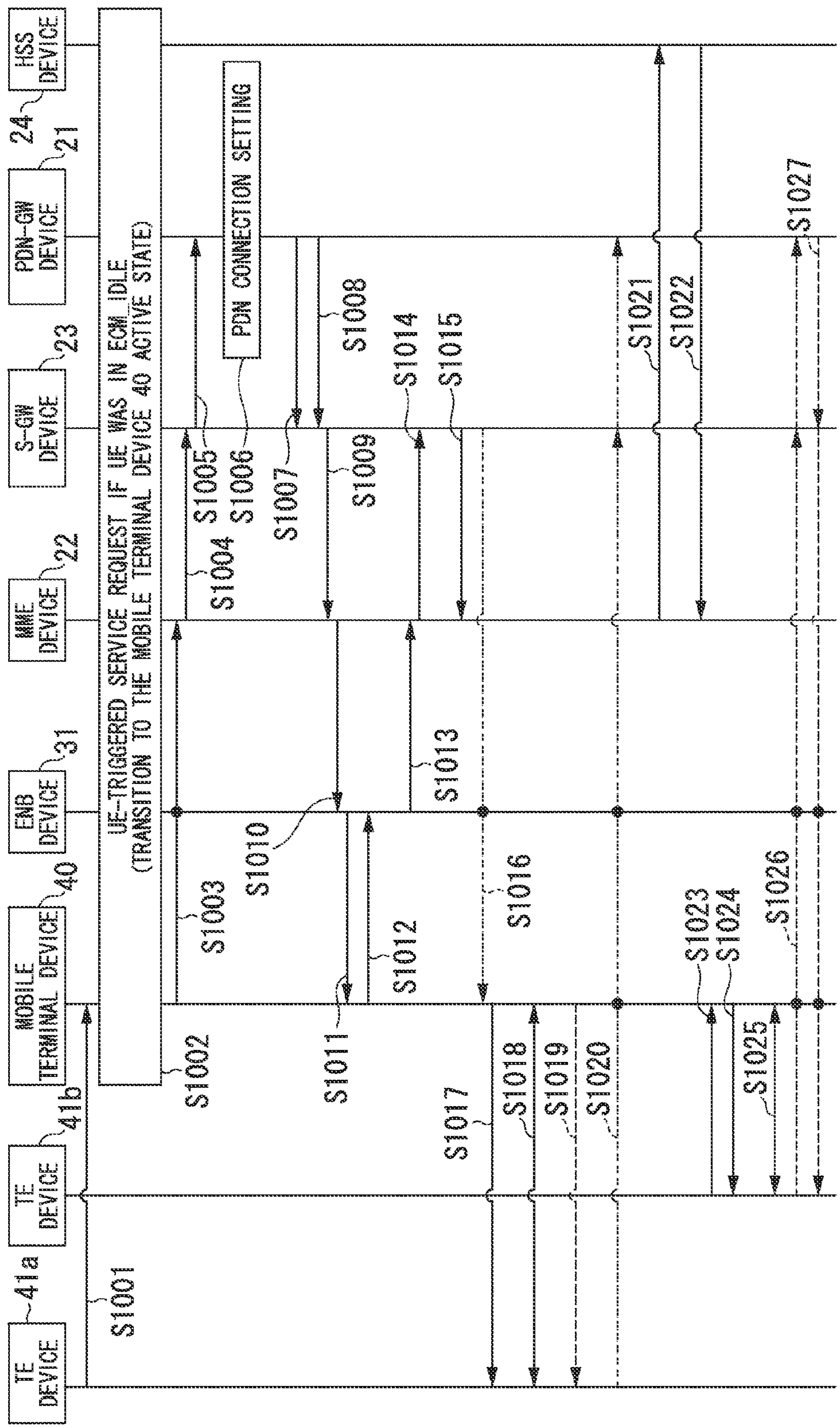

TE DEVICE
41a
TE DEVICE
41b
MOBILE TERMINAL DEVICE
40
ENB DEVICE
31
MME DEVICE
22
S-GW DEVICE
23
PDN-GW DEVICE
21
HSS DEVICE
24
UE-TRIGGERED SERVICE REQUEST IF UE WAS IN ECM_IDLE
(TRANSITION TO THE MOBILE TERMINAL DEVICE 40 ACTIVE STATE)
PDN CONNECTION SETTING
S1001
S1002
S1003
S1004
S1005
S1006
S1007
S1008
S1009
S1010
S1011
S1012
S1013
S1014
S1015
S1016
S1017
S1018
S1019
S1020
S1021
S1022
S1023
S1024
S1025
S1026
S1027

FIG. 11

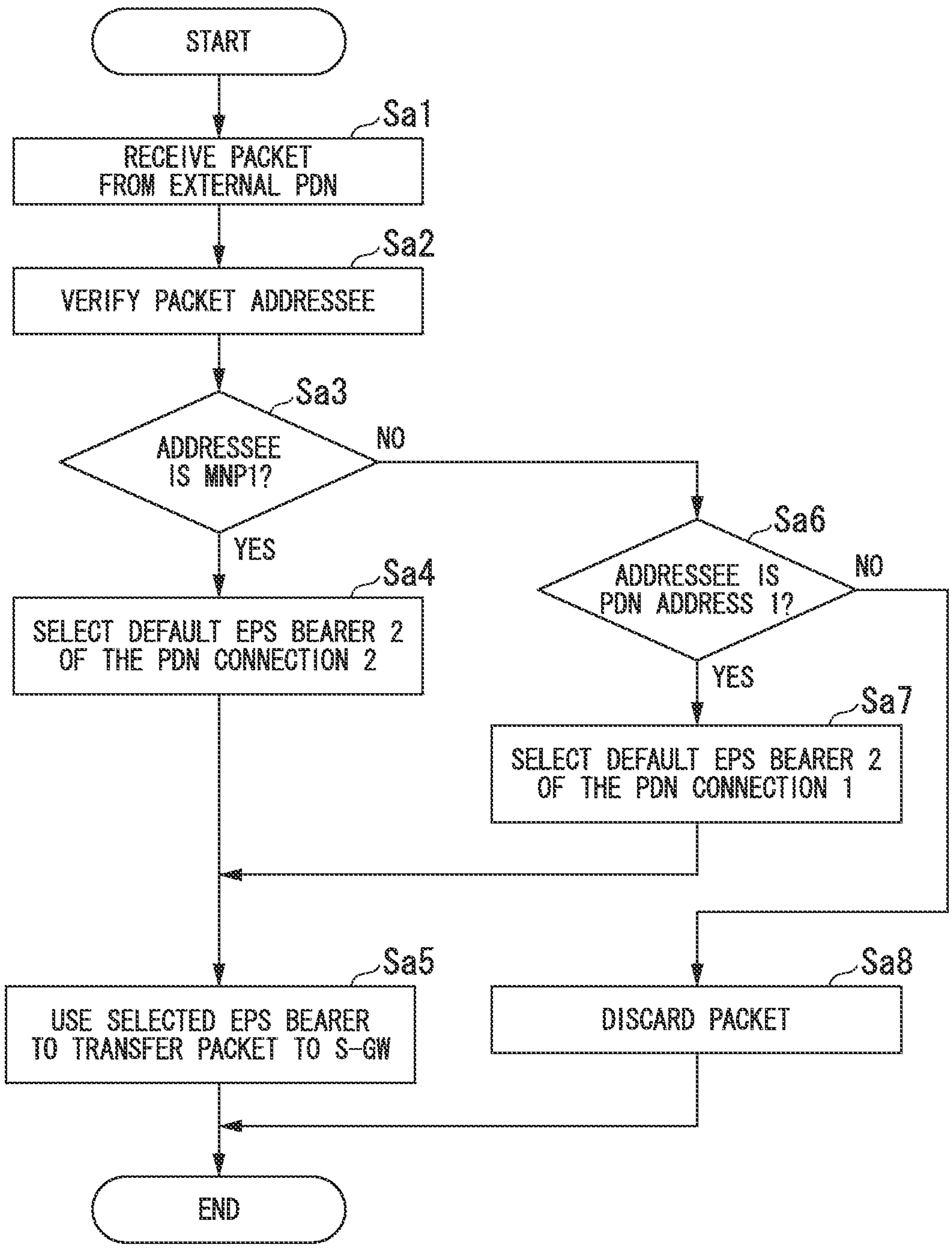

START
Sa1
RECEIVE PACKET FROM EXTERNAL PDN
Sa2
VERIFY PACKET ADDRESSEE
Sa3
ADDRESSEE IS MNP1?
NO
YES
Sa4
SELECT DEFAULT EPS BEARER 2 OF THE PDN CONNECTION 2
Sa6
ADDRESSEE IS PDN ADDRESS 1?
NO
YES
Sa7
SELECT DEFAULT EPS BEARER 2 OF THE PDN CONNECTION 1
Sa5
USE SELECTED EPS BEARER TO TRANSFER PACKET TO S-GW
Sa8
DISCARD PACKET
END

FIG. 12

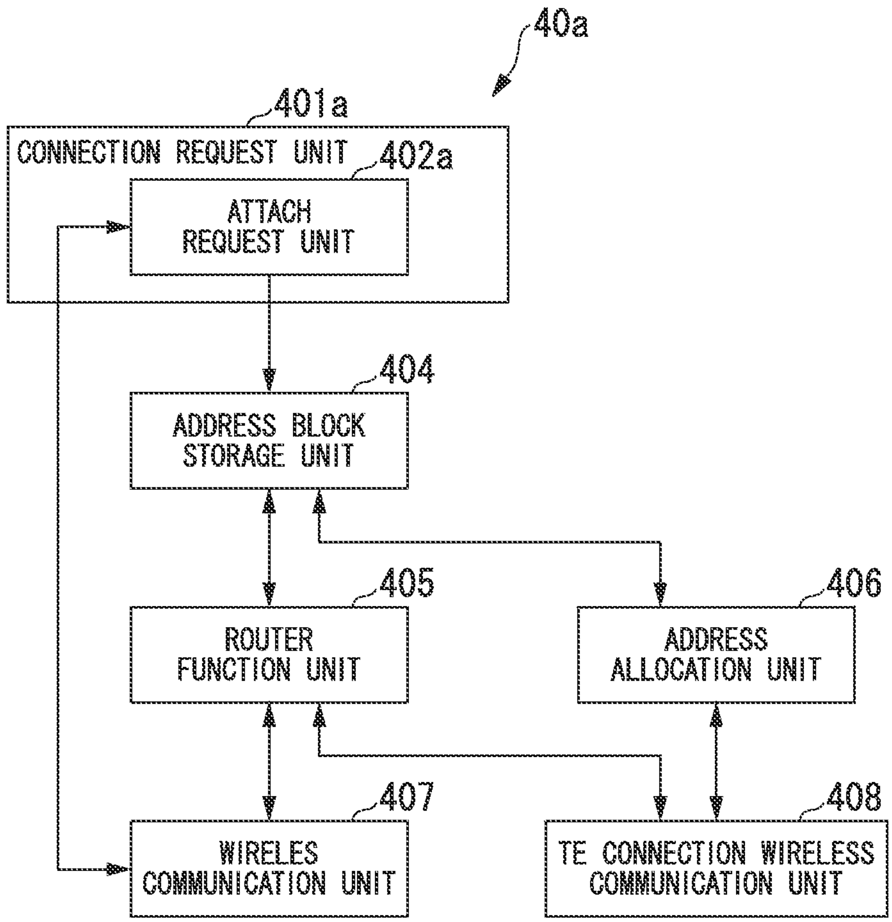
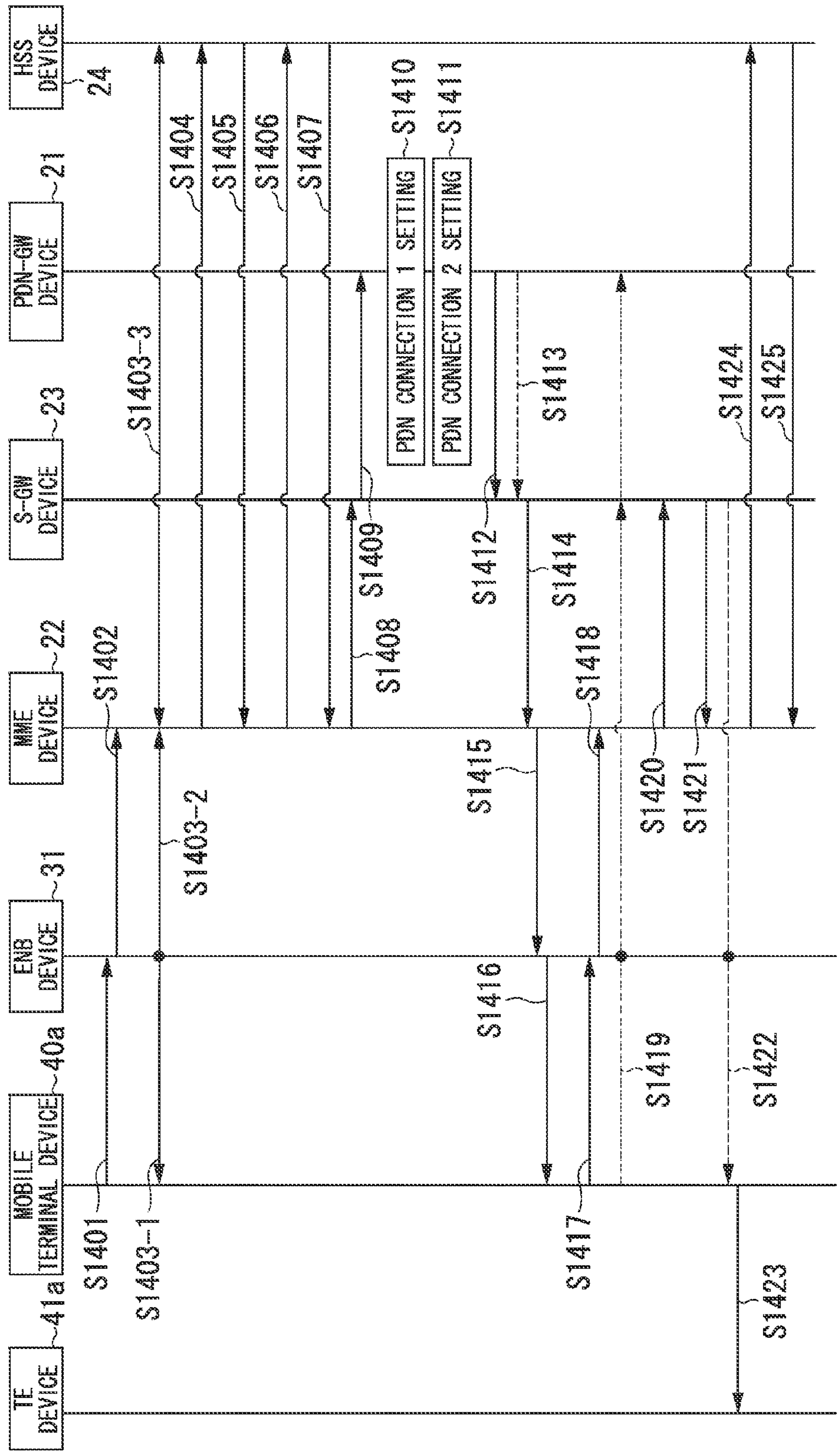

40a
401a
CONNECTION REQUEST UNIT
402a
ATTACH REQUEST UNIT
404
ADDRESS BLOCK STORAGE UNIT
405
ROUTER FUNCTION UNIT
406
ADDRESS ALLOCATION UNIT
407
WIRELES COMMUNICATION UNIT
408
TE CONNECTION WIRELESS COMMUNICATION UNIT

FIG. 13



TE DEVICE
41a
MOBILE TERMINAL DEVICE
40a
ENB DEVICE
31
MME DEVICE
22
S-GW DEVICE
23
PDN-GW DEVICE
21
HSS DEVICE
24
S1401
S1402
S1403-1
S1403-2
S1403-3
S1404
S1405
S1406
S1407
S1408
S1409
PDN CONNECTION 1 SETTING
S1410
PDN CONNECTION 2 SETTING
S1411
S1412
S1413
S1414
S1415
S1416
S1417
S1418
S1419
S1420
S1421
S1422
S1423
S1424
S1425

FIG. 14

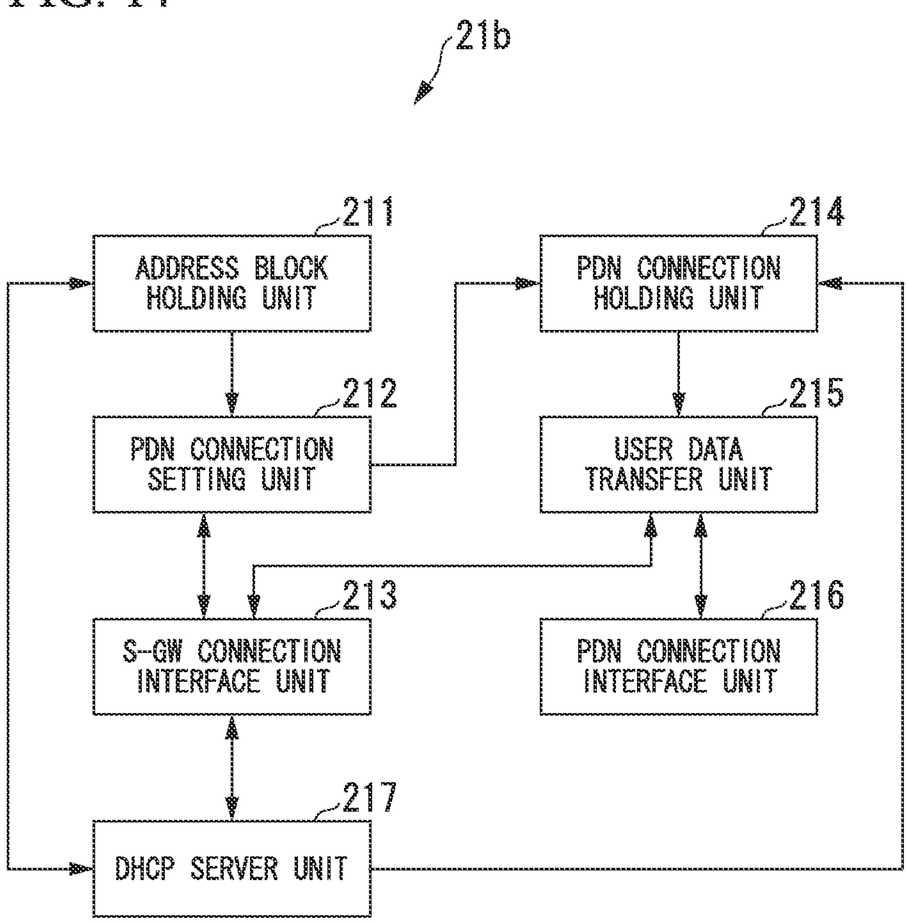

21b
211
ADDRESS BLOCK HOLDING UNIT
212
PDN CONNECTION SETTING UNIT
213
S-GW CONNECTION INTERFACE UNIT
214
PDN CONNECTION HOLDING UNIT
215
USER DATA TRANSFER UNIT
216
PDN CONNECTION INTERFACE UNIT
217
DHCP SERVER UNIT

FIG. 15

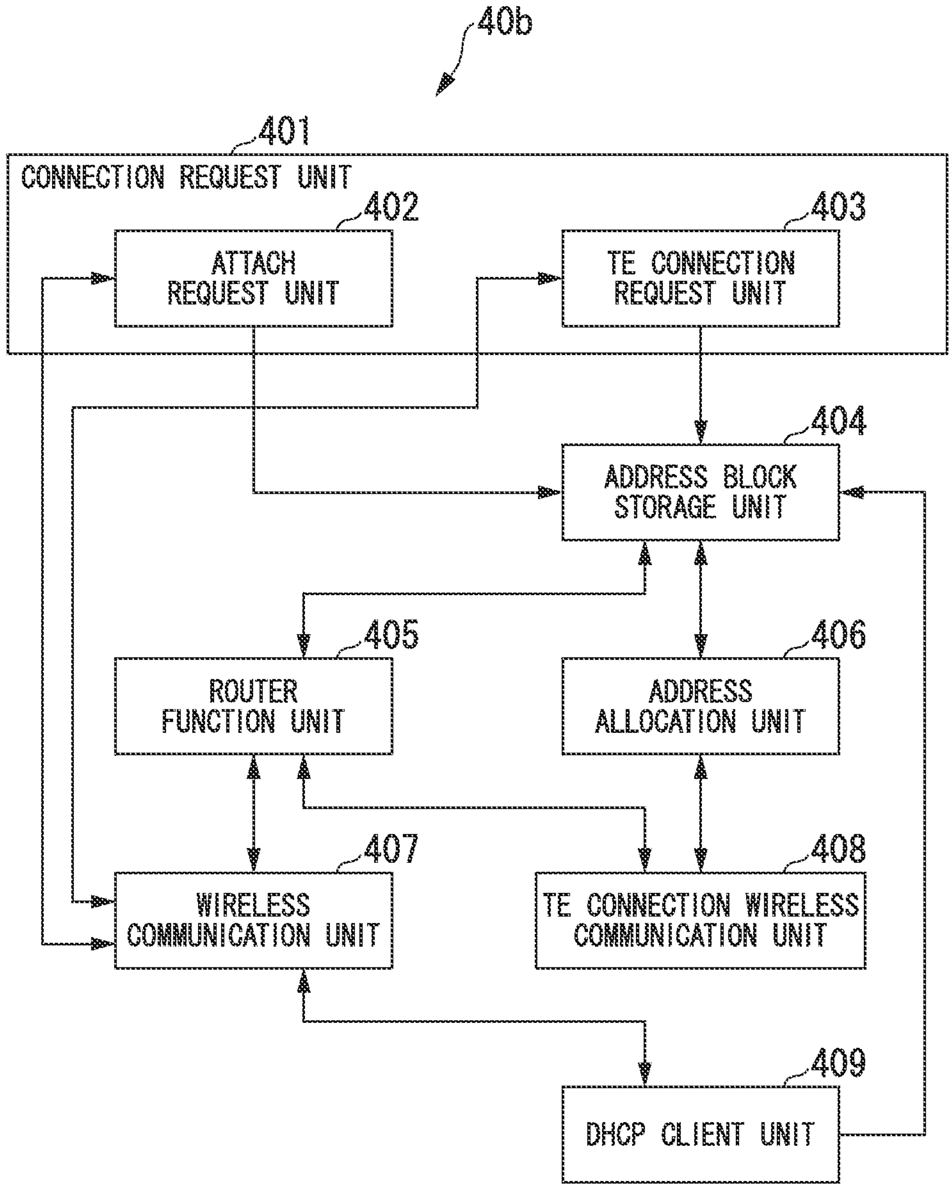

40b
401
CONNECTION REQUEST UNIT
402
ATTACH REQUEST UNIT
403
TE CONNECTION REQUEST UNIT
404
ADDRESS BLOCK STORAGE UNIT
405
ROUTER FUNCTION UNIT
406
ADDRESS ALLOCATION UNIT
407
WIRELESS COMMUNICATION UNIT
408
TE CONNECTION WIRELESS COMMUNICATION UNIT
409
DHCP CLIENT UNIT

FIG. 16

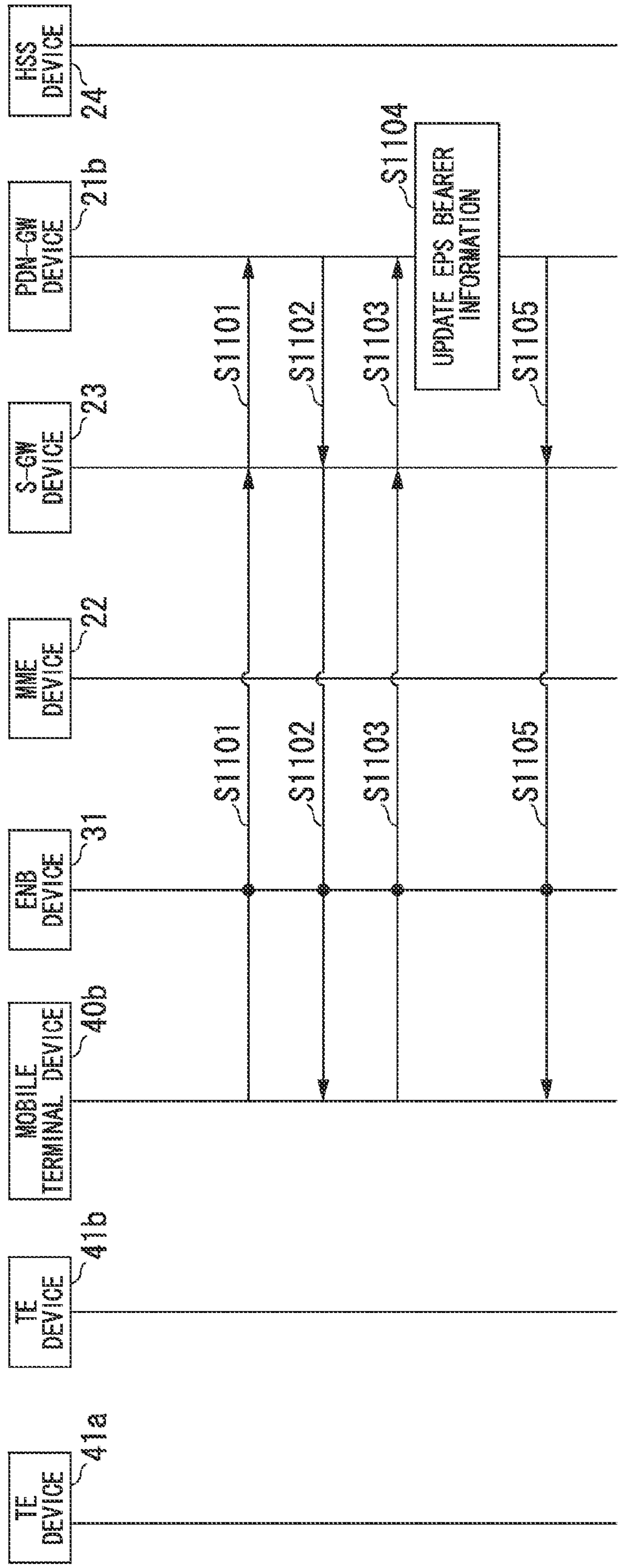

TE DEVICE
41a
TE DEVICE
41b
MOBILE TERMINAL DEVICE
40b
ENB DEVICE
31
MME DEVICE
22
S-GW DEVICE
23
PDN-GW DEVICE
21b
HSS DEVICE
24
S1101
S1102
S1103
S1104
UPDATE EPS BEARER INFORMATION
S1105

FIG. 17

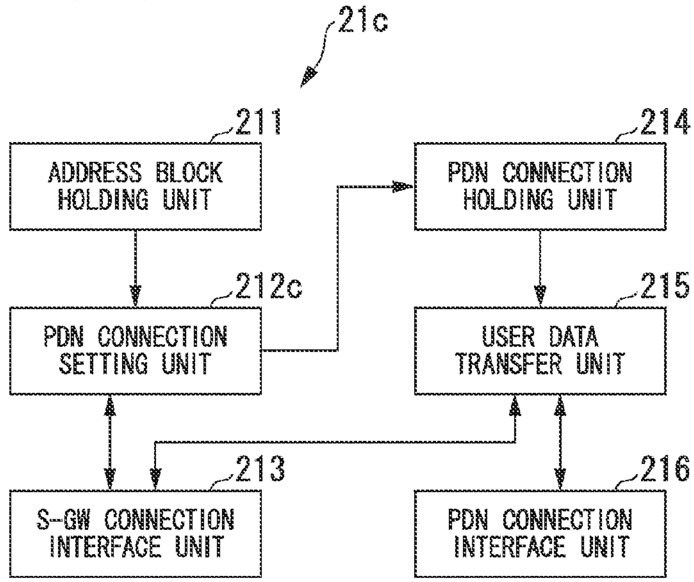

21c
211
ADDRESS BLOCK HOLDING UNIT
214
PDN CONNECTION HOLDING UNIT
212c
PDN CONNECTION SETTING UNIT
215
USER DATA TRANSFER UNIT
213
S-GW CONNECTION INTERFACE UNIT
216
PDN CONNECTION INTERFACE UNIT

FIG. 18

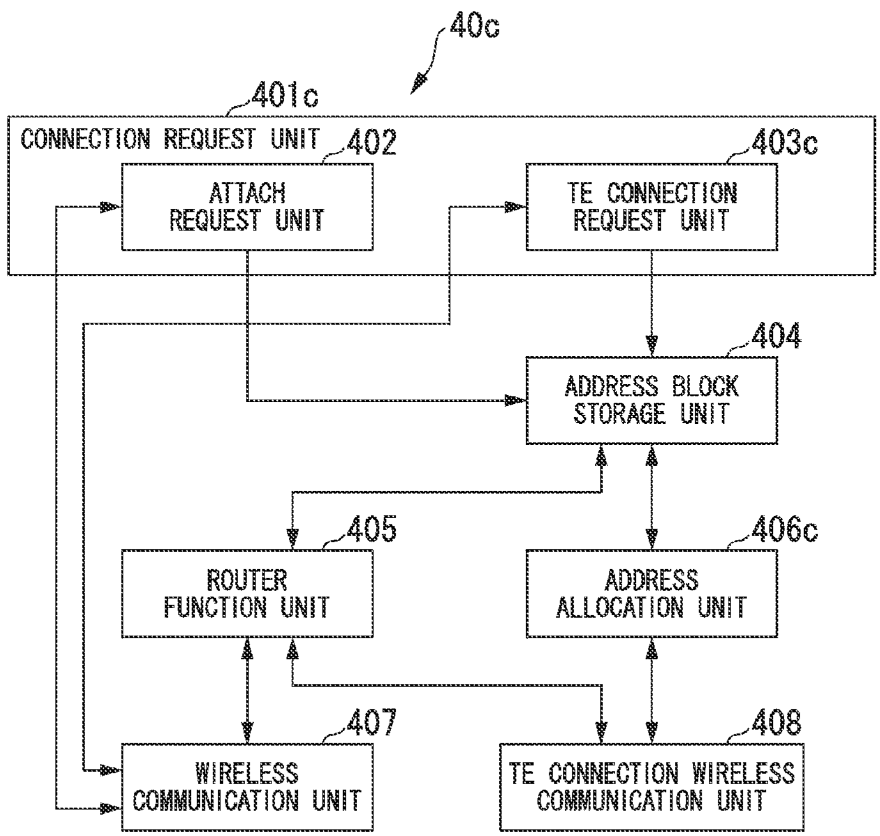

40c
401c
CONNECTION REQUEST UNIT
402
ATTACH REQUEST UNIT
403c
TE CONNECTION REQUEST UNIT
404
ADDRESS BLOCK STORAGE UNIT
405
ROUTER FUNCTION UNIT
406c
ADDRESS ALLOCATION UNIT
407
WIRELESS COMMUNICATION UNIT
408
TE CONNECTION WIRELESS COMMUNICATION UNIT

FIG. 19

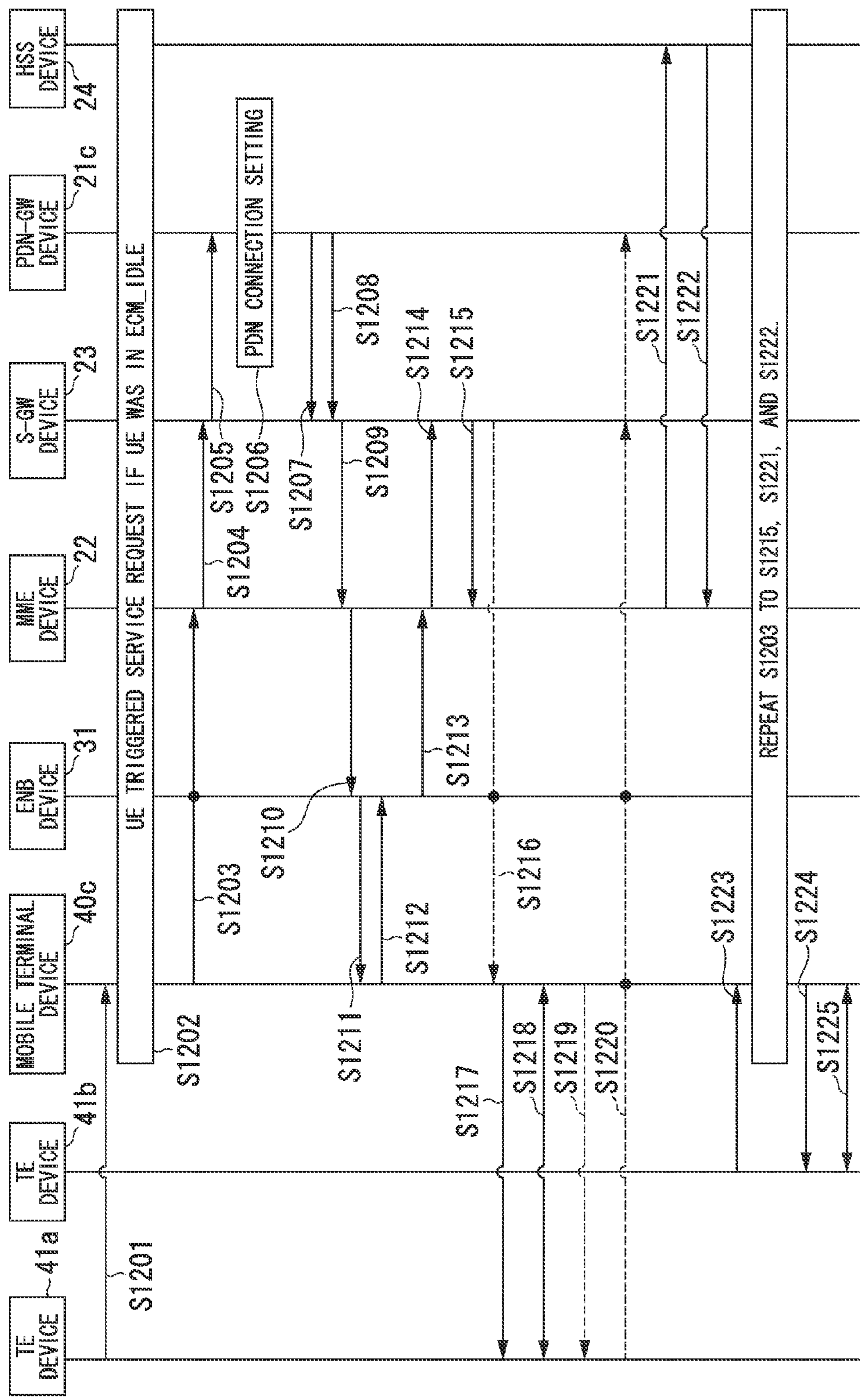

TE DEVICE
41a
TE DEVICE
41b
MOBILE TERMINAL DEVICE
40c
ENB DEVICE
31
MME DEVICE
22
S-GW DEVICE
23
PDN-GW DEVICE
21c
HSS DEVICE
24
UE TRIGGERED SERVICE REQUEST IF UE WAS IN ECM_IDLE
PDN CONNECTION SETTING
REPEAT S1203 TO S1215, S1221, AND S1222.
S1201
S1202
S1203
S1204
S1205
S1206
S1207
S1208
S1209
S1210
S1211
S1212
S1213
S1214
S1215
S1216
S1217
S1218
S1219
S1220
S1221
S1222
S1223
S1224
S1225

FIG. 20

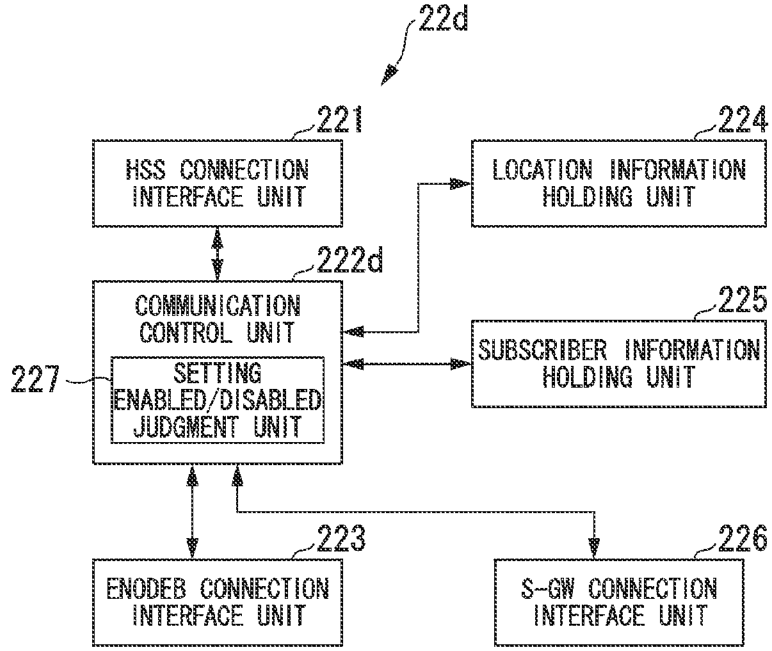

22d
221
HSS CONNECTION INTERFACE UNIT
224
LOCATION INFORMATION HOLDING UNIT
222d
COMMUNICATION CONTROL UNIT
225
SUBSCRIBER INFORMATION HOLDING UNIT
227
SETTING ENABLED/DISABLED JUDGMENT UNIT
223
ENODEB CONNECTION INTERFACE UNIT
226
S-GW CONNECTION INTERFACE UNIT

FIG. 21

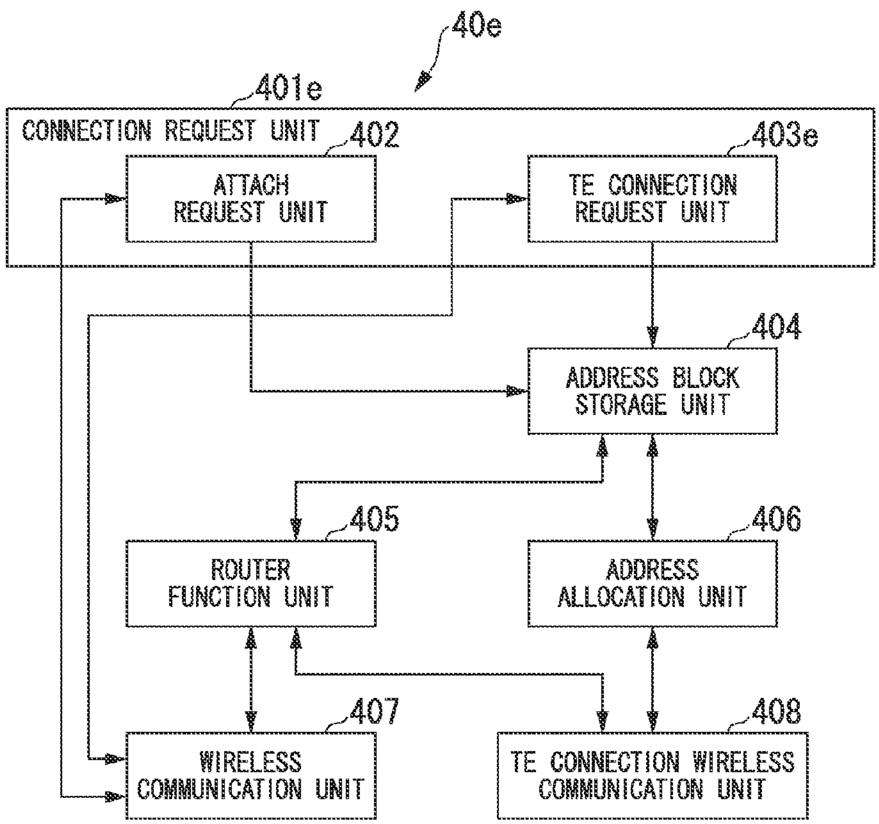
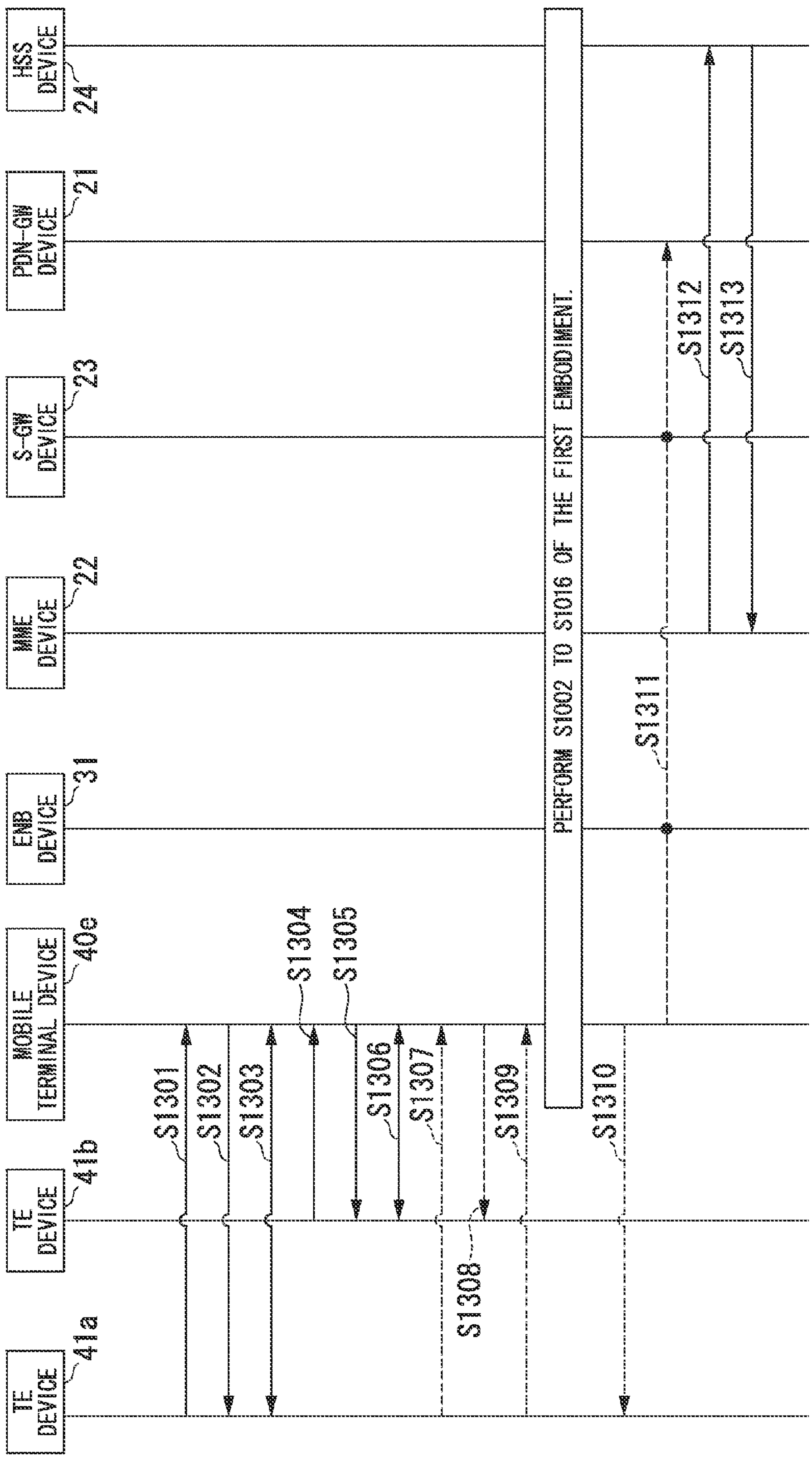

40e
401e
CONNECTION REQUEST UNIT
402
ATTACH REQUEST UNIT
403e
TE CONNECTION REQUEST UNIT
404
ADDRESS BLOCK STORAGE UNIT
405
ROUTER FUNCTION UNIT
406
ADDRESS ALLOCATION UNIT
407
WIRELESS COMMUNICATION UNIT
408
TE CONNECTION WIRELESS COMMUNICATION UNIT

FIG. 22



TE DEVICE
41a
TE DEVICE
41b
MOBILE TERMINAL DEVICE
40e
ENB DEVICE
31
MME DEVICE
22
S-GW DEVICE
23
PDN-GW DEVICE
21
HSS DEVICE
24
S1301
S1302
S1303
S1304
S1305
S1306
S1307
S1308
S1309
S1310
PERFORM S1002 TO S1016 OF THE FIRST EMBODIMENT.
S1311
S1312
S1313

# MOBILE COMMUNICATION SYSTEM

## TECHNICAL FIELD

The present invention relates to a mobile communication system, and particularly to a mobile communication system connected to an external packet data network.

The present application claims priority based on the patent application 2009-079962, filed on Mar. 27, 2009 in Japan, the content of which is incorporated herein by reference.

## BACKGROUND ART

In the UMTS (Universal Mobile Telecommunications System) that has been standardized as a third-generation mobile communication system, an MT (Mobile Terminal) is established as a mobile terminal that has a UMTS wireless interface and a TE (Terminal Equipment) is established as a terminal equipment that connects to the MT. The MT and TE are collectively called UE (User Equipment).

A TE-MT interface is set forth in the Non-Patent Document 1 (TS 27.060), wherein a communication protocol is indicated in which a TE such as a laptop PC (personal computer) that does not have a UMTS wireless interface connects to a PDN (Packet Data Network) that is an external network, via the UMTS wireless interface in an MT. Although the physical interface between the TE and MT can use not only a wired interface such as a serial cable or a USB (Universal Serial Bus) cable, but also can use a wireless interface such as Bluetooth (registered trademark) or the like, the use of the PPP (Point-to-Point Protocol) is called for.

Patent Document 1 discloses a method whereby, rather than a TE-MT interface, an Ethernet (registered trademark) and DHCP (Dynamic Host Configuration Protocol) are used to allocate an IP (Internet Protocol) address to the TE and make connection to the PDN. Additionally, it is assumed that it will be possible to use this TE-MT interface in the EPS (Evolved Packet System), which is standardized as the next-generation mobile communication system by the 3GPP (3rd Generation Partnership Project).

The protocol for connecting a UE to the PDN in an EPS is set forth in the Non-Patent Document 2 (TS 23.401). The UE, after first being attached to the wireless access network, establishes a logical path connection to the PDN, which is known as a PDN connection.

The PDN is uniquely identified by the APN (Access Point Name), and is connected to the core network via a PDN-GW, which is an external gateway equipment. The PDN connection is established individually for each PDN-GW that is connected to the UE. Even via one and the same PDN-GW, when connections are made to different PDNs, independent PDN connections are required.

One PDN connection combines a plurality of logical paths that is known as an EPS bearer when transferring a user IP packet, and it is further possible to assign a QoS (Quality of Service) class and a charging rule or the like to each EPS bearer. Therefore, using the UE packet transmission destination and transport protocol, it is possible to apply different QoS classes and charging rules to each IP packet, using a port number.

Patent Document 1: Japanese Unexamined Patent Application Publication (Translation of PCT Application) No. 2008-511222

Non-Patent Document 1: TS 27.060 Packet Domain; Mobile Station (MS) Supporting Packet Switched Services



Non-Patent Document 2: TS 23.401 General Packet Radio Service (GPRS) Enhancements for Evolved Universal Terrestrial Radio Access Network (E-UTRAN) Access

## DISCLOSURE OF INVENTION

### Problem to be Solved by the Invention

However, when a user is walking around carrying a plurality of TEs such as a PDA or a laptop personal computer that does not have a wireless interface for direct connection to an EPS and a mobile terminal device that alone can connect to an EPS as a UE, an ad-hoc network being formed that locally makes connection between these devices, and the TE being connected to the ad-hoc network uses the mobile terminal device as an MT to make connection to the PDN, there is a problem that the processing load increases as noted below, and there is a limitation on the service that can be provided.

Conventionally, PDN connections have been established for each TE. Therefore, even in the case in which a plurality of TEs are connected to one and the same PDN and also to one and the same PDN-GW, as many procedures for establishing PDN connections are necessary as there are TEs. The mobile terminal device itself to which the TE is connected is also connected to the EPS and establishes a PDN connection for the mobile terminal device in order to benefit from the communication service. However, with regard to any of these PDN connections, even though they are established from a common mobile terminal device as the point of origin, because they could not be combined, there was the problem of an increase in the processing load, because of the increase in the overall system administrative information. Additionally, at the time of handover as well, it is necessary to perform the protocol for re-establishing the PDN connections for all PDN connections, thereby causing an increase in the overall system processing load.

A method that can be envisioned so that the number of PDN connections does not increase is that of providing an NAT (Network Address Translator) in the above-noted mobile terminal device, and sharing one IP address allocated to the mobile terminal device and one PDN connection between the mobile terminal device and a plurality of TEs. In this case, however, not only does the installation into the mobile terminal device becomes complex, but also processing for the mobile terminal device to check all the packets transmitted and received by the TE becomes necessary and, if necessary, to rewrite the packet header and payload, thereby increasing the processing load on the mobile terminal device. This results in the problems of a reduced throughput and an increase in battery consumption of the mobile terminal device. Additionally, because a packet transmitted by the mobile terminal device itself and a packet that the TE transmits cannot be distinguished when seen from the viewpoint of the core network, the limitation occurs that, in spite of the fact that it is the origin of a packet transmission, the same QoS class and charging rule must be applied, this leading to the problem of hindering the implementation of a diverse service model in which different charging models are applied, depending upon the mode of use.

The present invention was made in consideration of the above-described situation and has as an object the provision of a mobile communication system capable of suppressing an increase in the processing load and a limitation of providable services, even in the case in which an ad-hoc network is formed between a mobile terminal device and a plurality of

TEs and a PDN connection is made by the TE using the mobile terminal device as an MT.

Means for Solving the Problem

(1) In an aspect of the present invention, there is provided a mobile communication system including a mobile terminal device performing a communication connection with a plurality of information terminal devices, a wireless access network performing wireless communication with the mobile terminal device, and a core network performing communication with an external packet data network, and also performing communication with the mobile terminal device via the wireless access network, wherein: the core network includes a PDN connection holding unit that associates and stores information regarding PDN connection that is a logical path used for transfer of user data via the wireless access network between the external packet data network and the mobile terminal device with information indicating an address block configured as a set of a plurality of addresses identifying a plurality of the information terminal devices.

(2) In the aspect of the present invention, the mobile terminal device may include: a connection request unit that requests the core network to set an information terminal PDN connection that is a PDN connection to be used for transfer of user data of the information terminal devices and that receives from the core network information indicating the address block assigned to the information terminal PDN connection set by the request; an address allocation unit that allocates an address belonging to an address block indicated by information received by the connection request unit to the information terminal devices; a router function unit that, when user data addressed to an address allocated to the information terminal devices is received, transfers the received user data to the information terminal devices to which the address is allocated; wherein the core network may include a PDN connection setting unit that, when a request is received from the mobile terminal device, allocates the address block to the PDN connection for the information terminal and associates and stores in the PDN connection holding unit information indicating the address block with information regarding the PDN connection for the information terminal, and transmits information indicating the allocated address block to the mobile terminal device.

(3) In the aspect of the present invention, the connection request unit of the mobile terminal device, when requesting the setting of the information terminal PDN connection, may specify an address block class that is a type of the address block allocated the information terminal PDN connection and that specifies one of an address block indicated by the IPv4 network address, an address block indicated by the IPv6 prefix, or an address block indicated by the IPv4 network address and by the IPv6 prefix, and wherein the PDN connection setting unit of the core network, when setting the information terminal PDN connection, may allocate to the set information terminal PDN connection the type of address block specified by the address block class.

(4) In the aspect of the present invention, the connection request unit of the mobile terminal device, when requesting the core network to set a PDN connection for a mobile terminal that is a logic path used for transfer of user data of the mobile terminal device with an external network, via the wireless access network, may include in the request a request for setting of the information terminal PDN connection.

(5) In the aspect of the present invention, the connection request unit of the mobile terminal device, when requesting the core network to set a PDN connection for a mobile terminal that is a logic path used for transfer of user data of the mobile terminal device between an external network and thereof, via the wireless access network, may include in the request a flag indicating that the mobile terminal device includes the router function unit, and wherein, the core network may include a setting enabled/disabled unit that, when a request to set the information terminal PDN connection is received, judges, based on the flag, whether the information terminal PDN connection can bet set.

(6) In the aspect of the present invention, the mobile terminal device may include an address block storage unit that stores information indicating the address block, and wherein the address allocation unit of the mobile terminal device, when the information terminal devices performs communication connection with the mobile terminal device, may allocate to the information terminal device an address that belongs to the address block stored by the address block storage unit.

(7) In the aspect of the present invention, the core network may include a terminal information storage unit that stores information indicating an address block allocated to the information terminal PDN connection in association with information that identifies the mobile terminal device, wherein the PDN connection setting unit of the core network, upon receiving a request for an information terminal PDN connection setting, may allocate the address block stored by the terminal information storage unit, in association with information identifying the mobile terminal device that originated the request.

(8) In the aspect of the present invention, the core network may include a terminal information storage unit that stores information indicating whether a user of a mobile terminal device is subscribed to a network mobile service, in association with information identifying the mobile terminal device, wherein the setting enabled/disabled judgment unit of the core network, upon receiving a request for setting of an information terminal PDN connection, may determine whether an information terminal PDN connection can be set, based on the flag in the request, and on information stored by the terminal information storage unit.

(9) In the aspect of the present invention, the core network may include a terminal information storage unit that stores information indicating whether or not a user of the mobile terminal is subscribed to a network mobile service, in association with information identifying the mobile terminal device, wherein the setting enabled/disabled judgment unit of the core network, upon receiving a request for setting of a mobile terminal PDN connection, may determine whether a mobile terminal PDN connection can be set, based on the flag in the request, and on information stored by the terminal information storage unit.

(10) In the aspect of the present invention, the mobile terminal device may include a dynamic host setting client unit that, using a dynamic host setting protocol, requests an address block from the core network, and receive from the core network information indicating the address block allocated to the information terminal PDN connection by the request, wherein the core network may include a dynamic host setting server unit that, upon receiving the request for the address block using the dynamic host setting protocol, allocate an address block to the information terminal PDN connection of the mobile terminal device that originated the request, and transmit the address block to the mobile terminal device.

(11) In the aspect of the present invention, the mobile terminal device may include: a connection request unit that requests the core network to set an information terminal PDN

connection that is a logical path used for transfer of user data of the information terminal device with the external PDN, and receives as a response to the request information indicating an address allocated to the information terminal PDN connection set by the request; an address allocation unit that allocates an address received by the connection request unit to the information terminal device; and a router function unit that, upon receiving user data addressed to the address allocated to the information terminal device, transfers the received user data to the information terminal to which the address had been allocated, wherein the core network, upon receiving a request from the mobile terminal device, may associate an address belonging to the address block allocated to the mobile terminal PDN connection used in transfer of user data of the mobile terminal device with information regarding the information terminal PDN connection for which setting was requested, store these in the PDN connection holding unit, and transmit the allocated address to the mobile terminal device.

## Effect of the Invention

According to the present invention, PDN connections for a plurality of terminal devices connected to a common mobile terminal device can be combined, and additionally the establishment of the PDN connection for the mobile terminal device and the establishment of the PDN connection for the mobile terminal device can be performed together, thereby enabling suppression of an increase in processing load and limitation of the providable service.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a simplified block diagram showing the network configuration of a mobile communication system according to a first embodiment of the present invention.

FIG. **2** is a simplified block diagram showing the configuration of a PDN-GW device **21** in the same embodiment.

FIG. **3** is a simplified block diagram showing the configuration of an S-GW device **23** in the same embodiment.

FIG. **4** is a simplified block diagram showing the configuration of an MME device **22** in the same embodiment.

FIG. **5** is a simplified block diagram showing the configuration of an HSS device **24** in the same embodiment.

FIG. **6** is a simplified block diagram showing the configuration of an ENB device **31** in the same embodiment.

FIG. **7** is a simplified block diagram showing the configuration of a mobile terminal device **40** in the same embodiment.

FIG. **8** is a simplified block diagram showing the configuration of a TE device **41***a* in the same embodiment.

FIG. **9** is a sequence diagram showing an example of the sequence of attaching the mobile terminal device **40** to an EPS in the same embodiment.

FIG. **10** is a sequence diagram showing an example of connection of the TE device **41***a* and the TE device **41***b* to the mobile terminal device **40** in the same embodiment.

FIG. **11** is a flowchart showing the packet transfer processing of the PDN-GW device **21** in the same embodiment.

FIG. **12** is a simplified block diagram showing the configuration of a mobile terminal device **40***a* in a second embodiment of the present invention.

FIG. **13** is a sequence diagram showing an example of the sequence of attaching the mobile terminal device **40***a* to an EPS in the same embodiment.

FIG. **14** is a simplified block diagram showing the configuration of a PDN-GW device **21***b* in a third embodiment of the present invention.



FIG. **15** is a simplified block diagram showing the configuration of a mobile terminal device **40***b* in the same embodiment.

FIG. **16** is a sequence diagram showing an example of the sequence of connection of the mobile terminal device **40***b* in the same embodiment.

FIG. **17** is a simplified block diagram showing the configuration of a PDN-GW device **21***c* in a fourth embodiment of the present invention.

FIG. **18** is a simplified block diagram showing the configuration of a mobile terminal device **40***c* in the same embodiment.

FIG. **19** is a sequence diagram showing an example of the sequence of the connection for the TE devices **41***a* and **41***b* performing communication with an external PDN **50** in the same embodiment.

FIG. **20** is a simplified block diagram showing the configuration of an MME device **22***d* in a fifth embodiment of the present invention.

FIG. **21** is a simplified block diagram showing the configuration of a mobile terminal device **40***e* in a sixth embodiment of the present invention.

FIG. **22** is a diagram showing an example of the sequence for establishing a TE PDN **21** connection in the same embodiment.

## BEST MODE FOR CARRYING OUT THE INVENTION

### First Embodiment

The first embodiment of the present invention is described below, with references made to drawings. FIG. **1** is a simplified block diagram showing the network configuration of a mobile communication system according to the first embodiment of the present invention. The mobile communication system **10** in this embodiment is connected to an external PDN (Packet Data Network) **50**, and has a core network **20**, a wireless access network **30**, and at least one mobile terminal device **40**. In the example shown in FIG. **1**, the mobile communication system **10** has TE devices **41***a* and **41***b* that are connected to the mobile terminal device **40**. Although this embodiment is described for the example of an EPS as the mobile communication system that is standardized by 3GPP, the present invention is not limited in this manner, and can be applied in the same manner to a mobile communication system that has a node configuration.

The core network **20** has a PDN-GW device **21**, an MME (Mobile Management Entity) device **22**, an S-GW device **23**, and an HSS (Home Subscriber Server) device **24**. The S-GW device **23** transmits and receives, as a local mobility anchor, packets from the ENB (eNodeB: base station device) **31** to which the mobile terminal device **40** is connected.

The PDN-GW device **21** is connected to the external PDN **50**, which is the Internet or an IMS (IP Multimedia Subsystem), and functions as a gateway that connects the core network **20** to these types of external PDNs **50**. The PDN-GW device **21** allocates an IP address and performs sorting by packet QoS. The PDN-GW device **21** and the S-GW device **23** may be constituted on one and the same physical node.

The MME (Mobility Management Entity) **22** is an entity that performs only signaling, and has as its main function management, including paging of mobility of the mobile terminal device **40** that connects to the wireless access network **30**.

The HSS device **24** performs user authentication and manages subscription data. Subscription data includes a subscriber's service subscription information, and whether the subscriber is subscribed to NEMO (Network Mobility) service. The wireless access network **30** has at least one ENB device **31**, which is a base station.

The mobile terminal device **40** is a device that has the functions of both an MT and a UE in UMTS. The TE devices **41***a* and **41***b* are TEs in UMTS.

GTP (General Packet Radio Service Tunneling Protocol) or GRE (Generic Routing Encapsulation) is used as the packet tunneling protocol between the S-GW device **23** and the PDN-GW device **21**. With GTP, exchange is performed of the TEIDs (Tunnel Endpoint IDs) between two nodes and two TEIDs are set individually for each direction. Because different TEIDs are allocated for each EPS bearer, the GTP endpoint node (S-GW device **23** or PDN-GW device **21**) references the TEM included in the packet header to be able to uniquely distinguish between the mobile terminal device **40** and its EPS bearer. Similar to GTP, GRE performs exchange of GRE keys, which correspond to the TEIDs in GTP, between two nodes, and sets two GRE keys (downlink GRE key and uplink GRE key) individually for each direction.

FIG. **2** is a simplified block diagram showing the configuration of the PDN-GW **21** in the present embodiment. The PDN-GW **21** has an address block holding unit **211**, a PDN connection setting unit **212**, an S-GW connection interface unit **213**, a PDN connection holding unit **214**, a user data transfer unit **215**, and a PDN connection interface unit **216**.

The S-GW connection interface unit **213** is a communication interface unit for performing communication connection with the S-GW device **23**. Each unit of the PDW-GW device **21** performs communication with the S-GW device **23**, via this S-GW connection interface unit **213**. The PDN connection interface unit **216** is a communication interface unit for performing communication with the external PDN **50**. Each unit of the PDN-GW device **21** performs communication with the external PDN **50**, via this PDN connection interface unit **216**.

The address block holding unit **211** holds information indicating an address block that can be allocated to the PDN connection by the PDN connection setting unit **212**, which is described later. An address block as used herein is a set of a plurality of addresses, and in the present embodiment is a network address in IPv4 (for example, 192.63.25.0/24 of 192.63.25.0 to 192.63.25.255) and an IPv6 prefix in IPv6 (for example, 1392:d38c::/32 of 1392:d38c:: to 1392:d38c:ffff:ffff::).

The PDN connection holding unit **214** stores information regarding a PDN connection, associating it with information that indicates an address block. The PDN connection in this case is a logical path used for transfer of user data, via the wireless access network **30**, between the external PDN **50** and the mobile terminal device **40**. There are two types of PDN connections, a PDN connection for UE (PDN connection for a mobile terminal) for transferring user data of the mobile terminal device **40**, and a PDN connection for a TE (PDN connection for an information terminal) for transferring user data of the information terminals **41***a* and **41***b*.

The PDN connection setting unit **212**, upon receiving a request from the mobile terminal device **40**, allocates an address block to a TE PDN connection or a UE PDN connection, associates information that indicates the address block with information that indicates the TE PDN connection or the UE PDN connection and causes the PDN connection holding unit **214** to store the information, and transmits information indicating the allocated address block, addressing it to the mobile terminal device **40**.

The user data transfer unit **215**, upon receiving user data from the external PDN **50**, accesses the PDN connection holding unit **214**, acquires PDN connection information associated with the address block included in the addressee of the received user data, and uses the PDN connection of the acquired information to transfer the received user data to the mobile terminal device **40**. The user data transfer unit **215**, upon receiving user data from the mobile terminal device **40**, via the S-GW device **23**, transfers it to the external PDN **50**. In the present embodiment, the user data from the mobile terminal device **40** includes user data of the mobile terminal device **40**, and user data of the information terminal devices **41***a* and **41***b* connected to the mobile terminal device **40**.

FIG. **3** is a simplified block diagram showing the configuration of the S-GW device **23** in the present embodiment. The S-GW device **23** has a PDN connection holding unit **231**, a user data transfer unit **232**, an ENODEB connection interface unit **233**, a PDN-GW connection interface unit **234**, a communication control unit **235**, and an MME connection interface unit **236**.

The ENODEB connection interface unit **233** is a communication interface unit for performing communication connection to the ENB device **31**. Each unit of the S-GW device **23** performs communication with the ENB device **31**, via the ENODEB connection interface unit **233**. The PDN-GW connection interface unit **234** is a communication interface unit for performing communication connection with the PDN-GW device **21**. Each unit of the S-GW device **23** performs communication with the PDN-GW device **21**, via the PDN-GW connection interface unit **234**. The MME connection interface unit **236** is a communication interface unit for performing communication connection with the MME device **22**. Each unit of the S-GW device **23** performs communication with the MME device **22**, via the MIME connection interface unit **236**.

The PDN connection holding unit **231** stores information regarding the PDN connection. The user data transfer unit **232**, upon receiving user information from the mobile terminal device **40**, via the END device **31**, transfers it to the PDN-GW device **21**, using the PDN connection that is stored by the PDN connection holding unit **231**. The user data transfer unit **232**, upon receiving the user data from the external PDN **50** via the PDN-GW device **21**, transfers it to the ENB device **31**, using the PDN connection that is stored in the PDN connection holding unit **231**.

FIG. **4** is a simplified block diagram showing the configuration of the MME device **22** in the present embodiment. The MME device **22** has an HSS connection interface unit **221**, a communication control unit **222**, an ENODEB connection interface **223**, a location information holding unit **224**, a subscriber information holding unit **225**, and an S-GW connection interface unit **226**. The HSS connection interface unit **221** is a communication interface unit for performing communication connection with the HSS device **24**. Each unit of the MME device **22** performs communication with the HSS **24**, via the HSS connection interface unit **221**.

The ENODEB connection interface unit **223** is a communication interface unit for performing communication connection with the ENB device **31**. Each unit of the MME device **22** performs communication with the ENB device **31**, via the ENODEB connection interface **223**. The S-GW connection interface unit **226** is a communication interface unit for performing communication connection with the S-GW device **23**. Each unit of the MME device **22** performs communication with the S-GW device **23**, via the S-GW connection interface unit **226**.

The location information holding unit **224** holds location information that indicates what ENB device **31** it is possible for each mobile terminal device **40** to communication with. The subscriber information holding unit **225** (terminal information storage unit) holds subscription data that includes service subscription information indicating which of mobile terminal devices **40** are subscribed to which service, associated with information identifying each of the mobile terminal devices **40**. In the present embodiment, this service includes NEMO (Network Mobility) service. Also, in the present embodiment, the subscription data includes a flag that indicates whether or not the mobile terminal device **40** has a router function. The location information and subscription data is the required data acquired by the MME device **22** from the HSS device **24**.

The communication control unit **222** controls communication of the MME device **22**, and has a setting enabled/disabled judgment unit **227**. The setting enabled/disabled judgment unit **227**, upon receiving an attach request from the mobile terminal device **40** (request for a UE PDN connection setting), via the ENB device **31**, makes a judgment as to whether the UE PDN connection that has been requested for setting can be set, based on a flag that indicates whether or not there is a router function being requested, and information included in the subscription data of the mobile terminal device **40** that indicates whether or not the mobile terminal device that originates the request is subscribed to the NEMO service. Details of this judgment are described later. The communication control unit **222** causes the subscriber information holding unit **225** to store the value of the flag that indicates whether or not a router function is provided.

The setting enabled/disabled judgment unit **227**, upon receiving a TE PDN connection setting request, via the ENB device **31**, makes the judgment of whether setting is possible of the requested TE PDN connection, based on a flag, stored by the subscriber information holding unit **225**, that indicates whether or not the mobile terminal device **40** has a router function. If the value of the flag indicates that the router function is provided, the judgment is settable, but if it indicates that the router function is not provided, the judgment is not settable.

FIG. **5** is a simplified block diagram showing the configuration of the HSS device **24** in the present embodiment. The HSS device **24** has an MME connection interface unit **241**, a control unit **242**, a location information holding unit **243**, and a subscriber information holding unit **244**. The MME connection interface unit **241** is a communication interface unit for performing communication connection with the MME device **22**. Each unit of the HSS device **24** performs communication with the MME device **22**, via the MME connection interface unit **241**.

The location information holding unit **243** holds location information of all the mobile terminal devices **40** that belong to the mobile communication system.

The subscriber information holding unit **244** holds subscription data for all mobile terminal devices **40** that belong to the mobile communication system **10**. The control unit **242** controls the overall HSS device **24**. The control unit **242** also, in response to a request from the MME device **22**, provides and updates location information held by the location information holding unit **243** and the subscription data held by the subscriber information holding unit **244**.

FIG. **6** is a simplified block diagram showing the configuration of the ENB device **31** in the present embodiment. The ENB device **31** has a wireless communication unit **311**, a communication control unit **312**, an S-GW connection interface unit **313**, and an MME connection interface unit **314**. The wireless communication unit **311** is a communication interface unit for performing communication connection with the mobile terminal device **40**. Each unit of the ENB device **31** performs communication with the mobile terminal device **40**, via the wireless communication unit **311**.

The communication control unit **312** controls communication in the ENB device **31**. The S-GW connection interface unit **313** is a communication interface unit for performing communication connection with the S-GW device **23**. Each unit of the ENB device **31** performs communication with the S-GW device **23**, via the S-GW connection interface unit **313**. The MME connection interface unit **314** is a communication interface unit for performing communication connection with the MME device **22**. Each unit of the ENB device **31** performs communication with the MME device **22**, via the MME connection interface unit **314**.

FIG. **7** is a simplified block diagram that shows the constitution of the mobile terminal device **40**. The mobile terminal device **40** has a connection request unit **401**, an address block storage unit **404**, a router function unit **405**, an address allocation unit **406**, a wireless communication unit **407**, and a TE connection wireless communication unit **408**. The connection request unit **401** has an attach request unit **402** and a TE connection request unit **403**. The wireless communication unit **407** is a communication interface for performing a communication connection with the ENB device **31**. Each unit of the mobile terminal device **40** performs wireless communication with the ENB device **31**, via this wireless communication unit **407**. The TE connection wireless communication unit **408** is a communication interface for performing a communication connection with the TE devices **41***a* and **41***b*. Each unit of the mobile terminal device **40** performs communication with the TE devices **41***a* and **41***b*, via this wireless communication unit **408**.

The attach request unit **402** makes an attach request (UE PDN connection setting) to the core network **20**, via the ENB device **31**, and receives information that indicates the IP address (IPv4 address or IPv6 prefix) that is allocated to the UE PDN connection set by the request from the core network **20**, via the ENB device **31**. This request includes a flag that indicates that the mobile terminal device **40** has a router function (router function unit **405**). The description of the subsequent communication that is performed between the mobile terminal device and the core network, via the ENB device **31**, is omitted herein.

The TE connection request unit **403** makes a TE PDN connection setting request to the core network **20**, via the ENB device **31**, and receives information that indicates the IP address (IPv4 network address or IPv6 prefix) that is allocated to the TE PDN connection set by the request from the core network **20**, via the ENB device **31**.

The address block storage unit **404** stores information that indicates the address blocks received by the attach request unit **402** and the TE connection request unit **403** of the connection request unit **401**. The address allocation unit **406** allocates an address that belongs to the address block indicated by the information received by the TE connection request unit **403** to the TE device **41***a*.

The router function unit **405**, upon receiving the user data addressed to the address allocated to the TE devices **41***a* and **41***b*, transfers the received user data to the TE device to which the address is allocated.

FIG. **8** is a simplified block diagram showing the configuration of the TE device **41***a* in the present embodiment. Because the TE devices **41***a* and **41***b* have the same configuration, the description will be of the configuration of the representative TE device **41***a*. The TE device **41***a* has a control unit **411** and an MT connection wireless communication unit **412**. The control unit **411** controls the overall TE device **41***a*. The MT connection wireless communication unit **412** is a communication interface unit for performing communication connection with a mobile terminal device **40** that has an MT function (modem function for making connection to the wireless access network **30**). The control unit **411** performs communication with the mobile terminal device **40**, via the MT connection wireless communication unit **412**.

The mobile terminal device **40**, by first performing attachment to the EPS, establishes its own PDN connection and default EPS bearer as a UE. FIG. **9** is a sequence diagram showing an example of the sequence of the mobile terminal device **40** attaching to the EPS. First, the attach request unit **402** of the mobile terminal device **40** transmits an attach request to the ENB device **31** (S**901**). This attach request includes therein subscriber identification information (IMSI: International Mobile Subscriber Identify) and user equipment function information (UE capability) that indicates the functions that the UE has. The user equipment function information includes an MR function capability (MR capability) flag that indicates the existence or non-existence of the MR (Mobile Router) function. In the case in which the mobile terminal device **40** functions as an MR (Mobile Router) and the MT of another plurality of TEs, the mobile terminal device **40** sends the attach request with this flag set to valid.

The ENB device **31** receives the above-noted attach request and transmits it to the MME device **22** (S**902**). The MME device **22** extracts the subscriber identification information included in the attach request and performs user authentication between the mobile terminal device **40** and the HSS device **24** (S**903**-**1** to S**903**-**3**). If the user authentication succeeds, in order to acquire the service subscription status of the subscriber, the MME device **22** transmits to the HSS device **24** the location information update message that includes the subscriber identification information included in the attach request at sequence S**902** (S**904**). Upon receiving the location information update message, the HSS device **24** transmits subscription data that indicates the specified contract information of the subscriber to the MME device **22** (S**905**).

The MME device **22** verifies from the acquired subscription data whether the subscriber has contracted for the NEMO service and, in the case in which, in spite of not being subscribed to the NEMO service, the MR function is requested, an attach refusal is transmitted to the mobile terminal device **40**, via the ENB device **31**, and the attach sequence is interrupted (attach failure). Further, if necessary, a notification is given to the user by the mobile terminal device **40** to the effect that there is no subscription to the NEMO service.

In the case in which, in spite of not being subscribed to the NEMO service the MR function is requested, rather than the MME device **22** sending the attach refusal and interrupting the attach sequence, the mobile terminal device PDN connection establishment processing noted below as steps S**906** and thereafter may be continuously performed, and at least communication performed by the mobile terminal device **40** may be permitted, regardless of whether or not there is a subscription to the NEMO service. In this case, however, the MME device **22**, upon receiving the PDN connectivity request at step S**1003** of FIG. **10** to be described later, at the stage of starting the TE PDN connection establishment protocol, based on either the subscription data acquired at the above-described step S**905** or the subscription data acquired once again from the HSS device **24**, a judgment is made as to whether or not the user has contracted for the NEMO service and, if the judgment is that subscription has not been made to the NEMO service, a PDN connection refusal is returned in the mobile terminal device **40**, and the TE PDN connection is not established, without transmitting the Bearer Setup Request of step S**1004**.

As a result of checking the subscription data acquired at sequence S**905**, if the subscriber has contracted for NEMO service, the MME device **22** transmits the subscription data ACK (Insert Subscriber Data Ack) to the HSS device **24** (S**906**). The HSS device **24** completes the updating of the location information of the mobile terminal device **40** in response to a location information update message at sequence **904**, and transmits a location information update ACK (Update Location Ack) to the MME device **22**.

Next, the MME device **22**, in order to establish a default EPS bearer between the S-GE device **23** and the PDN-GW device **21**, transmits a Bearer Setup Request to the S-GW device **23**. The Bearer Setup Request includes the subscriber's identification information, the IP address of the PDN-GW device **21**, the APN, the PDN connection ID**1**, the PDN type **1**, the PDN address **1**, and the EPS bearer ID**1**.

The APN (Access Point Name) uniquely defines the external PDN **50** to be connected, and the IP address of the PDN-GW device **21** and the APN are determined based on the subscription data acquired from the HSS device **24**, and with regard to the APN, the mobile terminal device **40** may be explicitly indicated by including it in the attach request transmitted at S**901**. The PDN connection ID is an identifier for the purpose of distinguishing among a plurality of PDN connections that are established to one and the same PDN-GW device **21** within one and the same PDN, at least within the PDN-GW device **21**. It is sufficient that the PDN connection ID distinguishes among a plurality of PDN connections that are established from the mobile terminal device **40** to one and the same PDN-GW device **21** within one and the same PDN, and rather than this being an independent information element, by making this a new identifier that is appended, for example, to the end of one APN, it may identify the individual PDN connections of a plurality of PDN connections established with a mobile terminal device **40** within a PSN-GW device **21**.

The PDN address indicates the IPv4 address or the IPv6 prefix, or both, allocated to the PDN connection that is established. In the case in which the address allocation is left up to the PDN-GW device **21**, the NULL address (address not specified) is stored, and in the case in which there is specification within the above-noted subscription data, that address may be used. The PDN type indicates the IP address type of the PDN address, and it is possible to specify an IPv4 address or an IPv6 prefix, or both. The EPS bearer ID is an identifier that distinguishes among a plurality of EPS bearers established by one mobile terminal device **40**.

The S-GW device **23** receives the Bearer Setup Request and starts the protocol to establish an EPS bearer with the PDN-GW device **23**. In the case in which GTP is used as the protocol to implement the EPS bearer, the S-GW device **23** transmits a Bearer Setup Request to the PDN-GW device **21** (S**909**). The Bearer Setup Request includes the subscriber's identification information, the S-GW device **23** IP address, the APN, the PDN connection ID**1**, the TEID**1** for the S-GW, the PDN type **1**, the PDN address **1**, and the EPS bearer ID**1**.

In the case in which GRE is used as the protocol to implement the EPS bearer, the S-GW device **23** transmits a Proxy Binding Update message to the PDN-GW device **21** (S**909**). The Proxy Binding Update includes the mobile network access identifier (MN_NA**1**: Mobile Node Network Access Identifier) generated from the identification information, the APN, the PDN connection ID**1**, the downlink GRE key **1**, the PDN type **1**, and the PDN address **1**.

The PDN-GW device **21**, upon receiving the Bearer Setup Request or the Proxy Binding Update at sequence S**909**, sets the PDN connection **1** (S**910**). In the setting of the PDN connection, the PDN-GW device **21** first, in the case in which a specific ID address has not been set in the PDN address **1** received at sequence S**909**, allocates an IPv4 address **1**, an IPv6 prefix, or both to the PDN address **1**. This PDN address is then allocated to the PDN connection **1**. Additionally, a default EPS bearer that is associated with the PDN connection **1** is established, and a user packet addressed and transferred to this PDN address **1** is linked to the above-noted EPS bearer that has been established.

Then, the PDN-GW device **21** returns to the S-GW device **23** either a bearer setup response or a Proxy Binding Acknowledgment (S**911**). In the case in which GTP is used in sequence S**911**, the bearer setup response includes the TEID**1** for the PDN-GW of the set PDN connection, the PDN type **1**, the PDN address **1**, and the EPS bearer ID**1**. In the case of using GRE, the Proxy Binding Acknowledgment is used and mobile network access identifier for the set PDN connection, the PDN connection ID**1**, the uplink GRE key **1**, the PDN type **1**, and the PDN address **1** are included within this message. Additionally, the PDN-GW device **21**, using the EPS bearer **1**, starts transmitting to the S-GW device **23** the user packet that was addresses to the PDN address **1** allocated to the PDN connection **1** set at sequence S**910** (S**912**).

The S-GW device **23**, upon receiving the Proxy Binding Acknowledgment or the bearer setup response at sequence S**911**, associates and records in a management table (PDN connection holding unit **231**) the PDN address **1** of these messages, the subscriber identification information, and the MME device **22**, and also transmits the Bearer Setup Response to the MME device **22** (S**913**). The bearer setup response includes the IP address of the S-GW device **23** of the set PDN connection **1**, the TEID**1** for the S-GW, the PDN type **1**, the PDN address **1**, and the EPS bearer ID**1**. The S-GW device **23** begins buffering the user packet transferred from the PDN-GW device **21**.

The MME device **22** receives the bearer setup response, and transmits an Attach Accept to the ENB device **31** (S**914**). This Attach Accept includes the ID address of the S-GW device **23** that received by the Bearer Setup Request, the APN, the PDN connection **1**, the TEID**1** for the S-GW, the PDN type **1**, the PDN address **1**, and the EPS bearer ID**1**. The ENB device **31** transmits to the mobile terminal device **40** the APN that received the Attach Accept as sequence S**914**, the PDN connection ID**1**, the PDN type **1**, the PDN address **1**, and the EPS bearer ID**1** (S**915**).

The mobile terminal device **40**, upon receiving the Attach Accept, acquires the PDN type **1** and PDN address **1** included in the received Attach Accept, and also transmits to the ENB device **31** an Attach Complete that includes the EPS bearer ID**1** included in the received Attach Accept (S**916**). Additionally, the mobile terminal device **40** transitions to a state in which user data can be transmitted and received. The ENB device **31**, upon receiving the Attach Complete, transmits to the MME device **22** an Attach Complete that includes the EPS bearer ID**1** included in the received Attach Complete, the IP address of the ENB device **31**, and the TEID**1** for the ENB (S**917**).

Thereafter, when the mobile terminal device **40** uses the PDN address acquired from the Attach Accept at sequence S**915** as the transmitting address of origin to transmit the user data addressed to the external PDN **50**, the user data is transferred by the bearer **1** within the established PDN connection **1** and, after transmission of the user data up to the PDN-GW device **21**, transmission is made to the external PDN **50** (S**918**).

The MME device **22**, upon receiving the Attach Complete at sequence S**917**, transmits to the S-GW device **23** a bearer update request that includes the IP address of the ENB device **31** included in this Attach Complete, the TEID**1** for the ENB, and the EPS bearer ID**1** (S**919**). The S-GW device **23**, upon receiving this bearer update request, acquires the IP address of the ENB device **31** included in the bearer update request, that is the IP address of the ENB device **31** to which the mobile terminal device **40** is connected, and returns to the MME device **22** the bearer update request that includes the IP address of the ENB device **31** that was included in the received bearer update request (S**920**). At this point, because the S-GW device **23** has acquired the IP address of the ENB device **31** to which the mobile terminal device **40** is connected, transmission to the ENB device **31**, including the buffered part directed at the mobile terminal device **40** that was transferred from the PDN-GW **21**, and the ENB device **31** transmits that user packet to the mobile terminal device **40** (S**921**). The above completes the attachment of the mobile terminal device **40** to the EPS.

Next, in order for the TE device **41**_a_ and the TE device **41**_b_ to perform communication with the external PDN **50**, connection is made to the mobile terminal device **40**. FIG. **10** is a sequence diagram that shows an example of the sequence of connection of the TE device **41**_a_ and the TE device **41**_b_ to the mobile terminal device **40**. The TE device **41**_a_ places the wireless communication interface unit **412** into the active state, and starts the IP address allocation protocol. The IP address allocation protocol may be an IPv6 Stateless Auto Configuration (IETF RFC 4862) or a DHC Pv4 (IETF RFC 2462) or a DHCPv6 (IETF RFC 3315), and is further not limited to these. The description herein uses the example of using the IPv6 Stateless Auto Configuration.

In order to find the default router, the TE device **41**_a_, sends an RS (Router Solicitation) (S**1001**). The mobile terminal device **40** receives the RS from the TE device **41**_a_ and if the mobile terminal device **40** itself has transitioned to the idle (IDLE) state within the EPS, it transitions to the active state in order to perform transmission and reception of communication data (S**1002**) (refer to TS 23.401, the 3GPP specifications). Then, in order to establish a new PDN connection **2** (TE PDN connection) for the TE device **41**_a_, the TE connection request unit **403** of the mobile terminal device **40** transmits a PDN Connectivity Request to the MME device **22** to the ENB device **31** (S**1003**).

The PDN Connectivity Request includes an APN and an MNP (Mobile Network Prefix) type (address block type). The APN used is what was acquired from the Attach Accept received from the ENB device **31** in the attach sequence shown in FIG. **9** and, similar to the case of sending the Attach Request at **S901**, the mobile terminal device **40** may be explicitly indicated. The MNP type is for specifying the address type of the network address (address block) allocated to the PDN connection that is established, and this is either an IPv4 type, which is an address block specified by an IPv4 (Internet Protocol Version 4) network address, or a IPv6 type, which is an address block specified by an IPv6 (Internet Protocol Version 6) prefix, or specified as both. However, this MNP type may be a new address type that extends the PDN type used in the attach sequence of FIG. **9**, and may be specified in combination with the PDN type.

The communication control unit **222** of the MME device **22** receives the PDN Connectivity Request and, in order to establish the PDN connection **2**, transmits a Bearer Setup

Request to the S-GW device **23** (S**1004**). However, in the case in which the attach processing is continued with the MR function at sequence S**906** of FIG. **9** remaining disabled, a PDN Connectivity Refusal is returned to the mobile terminal device **40**, and the connection sequence is terminated.

The Bearer Setup Request includes, in addition to the APN and MNP type that are included in the PDN Connectivity Request at sequence S**1003**, the subscriber identification data, the IP address of the PDN-GW device **21**, the PDN connection ID**2**, the MNP**1**, and the EPS bearer ID**2**. The MNP (Mobile Network Prefix) indicates the IPv4 sub-network address or the IPv6 prefix allocated to the PDN connection to be established for the mobile terminal device **40**, or both. However, the same information elements as the PDN address may be used for this MNP.

In the case in which the Ipv4 sub-network address or IPv6 prefix allocations are left up to the PDN-GW device **21**, the communication control unit **222** stores a NULL address (address not specified). However, in the case in which the mobile terminal device **40** that is the source of the request within the subscription data acquired from the HSS device **24** during the attach procedure of FIG. **9** and stored in the subscriber information holding unit **225** is associated with the information to be identified, and in which the MNP, which is information indicating an address block allocated to the TE PDN connection is specified, that value is stored in the MNP in this Bearer Setup Request (each of the IPv4 sub-network address **2** and the IPv6 prefix **2**).

The S-GW device **23** receives the Bearer Setup Request at sequence S**1004**, and begins the procedure for establishing a default EPS bearer for the TE device **41***a* with the PDN-GW device **21**. In the case in which GTP is used as the protocol for implementing the EPS bearer, the S-GW device **23** transmits the Bearer Setup Request to the PDN-GW device **21** (S**1005**). This Bearer Setup Request includes the subscriber identification information, the IP address of the S-GW device **23**, the APN, the PDN connection ID**2**, the TEID**2** for the S-GW, the MNP type, MNP**1**, and the EPS bearer ID**2**. This is different from the Bearer Setup Request at sequence S**909** in FIG. **9** in that the MNP type **1** and the MNP**1** are included in place of the PDN type **1** and the PDN address **1**.

In the case in which the GRE is used as the protocol for implementing the EPS bearer, the S-GW device **23** transmits a Proxy Binding Update message to the PDN-GW device **21**. The Proxy Binding Update message includes the mobile network access identifier generated from the subscriber identification information, the APN, the PDN connection ID**1**, the downlink GRE key, the MNP type **1**, and the MNP**1**. This Proxy Binding Update also differs from the Proxy Binding Update at sequence S**909** of the sequence in FIG. **9** in that the MNP type **1** and the MNP**1** are included in place of the PDN type **1** and the PDN address **1**.

The PDN connection setting unit **212** of the PDN-GW device **21** receives a Bearer Setup Request or a Proxy Binding Update at sequence S**1005**, and begins the setting of the PDN connection **2** (S**1006**). First, the PDN connection setting unit **212**, in the case in which a specific IPv4 sub-network address and a specific IPv6 prefix are not specified in the MNP**1**, allocates, from the address block pool held by the address block holding unit **211**, an address block of the type specified by the MNP**1** of the Bearer Setup Request or the Proxy Binding Update, that is, an IPv4 sub-network address **2** or IPv6 prefix **2** or both to the MNP**1**. The PDN connection **2** is then allocated to the MNP**1**. Additionally, a default EPS bearer **2** that is associated with the PDN connection **2** is established. When this is done, the PDN connection setting unit **212** causes the PDN connection holding unit **214** to store information indicating the address block allocated to the MNP**1** and information regarding the PDN connection **2**.

By doing this, the user data transfer unit **215** joins user data addressed to the MNP**1** from the external PDN **50** to the above-noted EPS bearer **2** that has been established. Addressing to the MNP**1** indicates that the user data allocated to the address belonging to the address block of the MNP**1**.

Then, the PDN-GW device **21** returns to the S-GW device **23** either a bearer setup response or a Proxy Binding Acknowledgment (S**1007**). In the case in which GTP is used, the bearer setup response is used at this sequence S**1007**, and the bearer setup response includes the TEID**2** for the PDN-GW, MNP**1**, and the EPS bearer ID**2**. In the case of using GRE, the Proxy Binding Acknowledgement is used, and the message includes therein the mobile network access identifier, the PDN connection ID**2**, the uplink GRE key **2**, the MNP type **1**, and MNP**1**. Additionally, the transfer of the user packet addressed to MNP**1** from the external PDN **50** up to the S-GW device **23** is started (S**1008**).

The packet transfer process that the PDN-GW device **21** starts at sequence S**1008** will now be described. FIG. **11** is a flowchart showing the packet transfer of the PDN-GW device **21**. First, the PDN-GW device **21**, upon receiving a packet from the external PDN **50** (Sa**1**), checks the addressee of the packet (Sa**2**). The PDN-GW device **21** judges whether or not the destination of the pack is MNP**1** (refer to sequence S**1004** in FIG. **10**) (Sa**3**), and if this is the case (YES at Sa**3**), selects the default EPS bearer (bearer between the external PDN **50** and the TE device **41***a*) corresponding to MNP**1** (Sa**4**), after which it transitions to step Sa**5**.

At step Sa**3**, if the judgment is that there is no agreement (NO at Sa**3**), transition is made to step Sa**6**, and the PDN-GW **21** judges whether the destination of the packet agrees with the PDN address **1** (refer to sequence S**908** in FIG. **9**) (Sa**6**) and, if the judgment is that there is agreement (YES at Sa**4**), after selecting the default EPS bearer (bearer between the external PDN **50** and the mobile terminal device **40**) of the PDN connection **1** corresponding to the PDN address **1**, transition is made to step Sa**5**.

At step Sa**5**, using the EPS bearer selected at the previous step (step Sa**4** or Sa**7**), the packet received at step Sa**1** is transferred to the S-GW device **23**, and the processing is terminated. If the judgment is made at step Sa**6** that there is no agreement (NO at Sa**6**), the PDN-GW device **21** judges that the packet received at step Sa**1** is not a packet destined for the currently managed mobile terminal device **40** or TE device **41***a*, discards the packet (Sa**8**) and terminates processing. Although the example described here is that of one mobile terminal device **40** connected to the TE device **41***a*, in the case in which a plurality of mobile terminal devices **40** or TE devices **41***a* have connections established with the PDN-GW device **21**, the same type of processing is performed for these devices as well before discarding the packet.

Returning to FIG. **10**, when the bearer setup response or Proxy Binding Acknowledgment of sequence S**1007** is received, the S-GW device **23** associates MNP**1**, the subscriber identification information, and the MME device **22** and stores them in a management table (PDN connection holding unit **231**), and also transmits a bearer setup response to the MME device **22** (S**1009**). The bearer setup response includes the IP address of the S-GW device **23**, the TEID**2** for the S-GW, the MNP type **1**, MNP**1**, and the EPS bearer ID**2**. The S-GW device **23** begins buffering the user packet addressed to MNP**1** transferred from the PDN-GW device **21**.

The MME device **22** receives the bearer setup response, and transmits a PDN Connectivity Accept to the ENB device **31** (S**1010**). The PDN Connectivity Accept includes the IP address of the S-GW device **23**, the APN, the PDN connection ID**2**, the TEID**2** for the S-GW, the MNP type **1**, MNP**1**, and the EPS bearer ID**2**. The ENB device **31** that receives the PDN Connectivity Accept transmits to the mobile terminal device **40** a PDN Connectivity Accept that includes the APN, the PDN connection ID**2**, the MNP type **1**, MNP**1**, and the EPS bearer ID**2** (S**1011**).

The mobile terminal device **40** receives the PDN Connectivity Accept, acquires the MNP type **1** and MNP**1**, and transmits to the ENB device **31** an RRC Connection Reconfiguration Complete that includes the EPS bearer ID**2** (S**1012**). The ENB device **31**, upon receiving the RRC Connection Reconfiguration Complete, transmits to the MME device **22** a bearer setup response that includes the IP address of the ENB device **31**, the TEID**2** for the ENB, and the EPS bearer ID**2** (S**1013**).

The MIME device **22**, upon receiving the bearer setup response, transmits to the S-GW device **23** a Bearer Update Request that includes the IP address of the ENB device **31**, the TEID**2** for the ENB, and the EPD bearer ID**2** (S**1014**). Upon receiving the Bearer Update Request, the S-GW device **23** returns to the MME device **22** a Bearer Update Request that includes the EPS bearer ID**2** (S**1015**). Because the S-GW device **23** acquires the IP address of the ENB device **31** to which the TE device **41***a* is connected from the Bearer Update Request of sequence S**1014**, the transfer to the ENB device **31** of the part of the user packet addressed to the TE device **41***a* that has been transferred from the PDN-GW device **21** and buffered is also begun, and the ENB device **31** transfers that user packet to the mobile terminal device **40** (S**1016**).

The mobile terminal device **40** that transmitted the RRC Connection Reconfiguration Complete to the BNB device **31** at sequence S**1012** uses the acquired MNP**1** to allocate an IP address to the TE device **41***a*. Although in this description the IPv6 prefix **2** set into MNP**1** is set, it would be similar in the case in which the IPv4 sub-network address is set. Also, when both the IPv4 sub-network address and the IPv6 prefix **2** are set, one of the protocols supported by the TE device **41***a* is selected and used.

First, the mobile terminal device **40** generates an RA (Router Advertisement) that sets the IPv6 prefix **2**, and transmits this to the TE device **41***a* (S**1017**). The TE device **41***a*, upon receiving the Router Advertisement, extracts the IPv6 prefix **2** from the Router Advertisement and automatically generates an IPv6 address. Also, DAD (Duplicate Address Detection) with respect to the generated address is performed with the mobile terminal device **40** to verify that the generated address is unique (S**1018**).

When the TE device **41***a* verifies by duplicate address detection that the IPv6 address is unique, it becomes possible to transmit and receive user data via the MT connection wireless communication unit **412**. The user packet addressed to MNP**1** and transferred from the PDN-GW **21** is transferred up to the mobile terminal device **40** via the S-GW device **23** and the ENB device **31**, and the mobile terminal device **40** transfers it to the TE device **41***a* via the TE connection wireless communication unit **408** (S**1019**).

When the mobile terminal device **40** receives the user packet from the TE device **41***a*, the routing function of the mobile terminal device **40** routes the user data in accordance with the transmission destination address of the user data. In the case in which the transmission destination address is MNP**1** or the mobile terminal device **40** itself, the mobile terminal device **40** transfers it directly to the addressee. For any other transmission destination address, the user data is transferred to the EPS bearer within the established PDN connection **2**, and is transferred up to the PDN-GW device **21** and transmitted to the external PDN **50** by the PDN-GW device **21** (S**1020**).

The MME device **22**, after receiving the Bearer Update Response of the sequence S**1015**, transfers the Location Information Update Request to the HSS device **24** (S**1021**). This Location Information Update Request includes information of the established PDN connection **2**, and includes the APN, the PDN connection ID**2**, the IP address of the PDN-GW device **21**, the MNP type **1**, and MNP**1**. The HSS device **24**, upon receiving this Location Information Update Request it stores this information into the subscriber's subscription data, so that when the mobile terminal device **40** re-attaches to the EPS and performs a PDN Connectivity Request, when the power is turned on or off, or the like, the same MNP**1** is allocated. The HSS device **24** also transmits the Location Information Update Request to the MME device **22** (S**1022**).

After the above, when a TE device **41***a* is connected anew to the mobile terminal device **40** and transmits a Router Solicitation (S**1023**), the mobile terminal device **40**, without establishing a new PDN connection, performs allocation of an IP address, using the MNP**1** that had already been acquired for the TE device **41***a*. That is, similar to the case of sequence S**1017**, the mobile terminal device **40** transmits to the TE device **41***b* a Router Advertisement that sets the IPv6 prefix **2** (S**1024**). The TE device **41***b*, upon receiving the Router Advertisement, executes the generation of an IP address and Duplicate Address Detection (S**1025**), similar to the TE device **41***a*, and transmitting and receiving user data with the external PDN **50** becomes possible (S**1026**, S**1027**). The sequences S**1023** to S**1025** are applied to every TE from the second and subsequent units.

After the TE device **41***a* connects to the mobile terminal device **40**, without waiting for the RRC Connection Reconfiguration Complete (sequence S**1012**) of the mobile terminal device **40**, in the case in which the TE device **41***b* has connected to the mobile terminal device **40**, the mobile terminal device **40**, without performing a PDN Connectivity Request anew, waits for the PDN Connectivity Accept of sequence S**1011**, and transmits to the TE device **41***b* the Router Advertisement that sets the MNP**1** for which notification was made by the PDN Connectivity Accept.

In the case in which DHCP is used as the method for allocating an IP address to the TE, the IPv4 sub-network address **2**, the IPv6 prefix, or both, which are acquired from MNP**1** at the sequence S**1011** are recorded as the address pool in the DHCP server within the mobile terminal device **40**, and a DHCP Offer (IP address provision notification) that includes the allocated IP address is transmitted to the TE that has sent the DHCP Request (IP address allocation request notification).

In this manner, in the present embodiment, by a PDN Connectivity Request, the mobile terminal device **40** acquires one address block (one IPv6 prefix or one IPv4 sub-network address, or both), and shares it with a plurality of TEs that are connected to the mobile terminal device **40**. By doing this, regardless of the number of TEs that are connected, it is possible to simultaneously connect a plurality of TEs to the external PDN **50** by establishing only one PDN connection.

Because communication between TEs is solved by routing between TE and UE (mobile terminal device **40**), this can be implemented without using the resources of the core network **20** and the wireless access system **30**. Additionally, because it is possible to set a QoS or a charging rule in units of EPS bearers, it is possible to allocate a QoS class and charging rule separately to user data that is transmitted and received by the mobile terminal device **40** itself via the external PDN **50**, and to user data that is transmitted and received with each TE via the external PDN **50**.

In this manner, the communication system of the present embodiment allocates one PDN connection and provides a connection to the external PDN **50** to a plurality of TEs (TE devices **41***a* and **41***b*) connected to the one mobile terminal device **40** that functions as both a UE and an MT. By doing this, it is possible to reduce the overall communication system administrative information, and to reduce the number of signaling messages.

## Second Embodiment

The second embodiment of the present invention is described below, with references made to drawings. The mobile communication system **10***a* in the present embodiment has a configuration similar to that of the mobile communication system **10** of the first embodiment, although it differs in that, in place of the mobile terminal device **40**, it is provided with a mobile terminal device **40***a*. By doing this, in contrast to the first embodiment, in which, after completion of the establishment of the PDN connection **1** for the UE, a PDN connection for the TE is established, in the present embodiment the establishment of the PDN connection for the TE is done simultaneously with the EPS attach of the UE.

FIG. **12** is a simplified block diagram showing the configuration of the mobile terminal device **40***a* in the present embodiment. The mobile terminal device **40***a* has a connection request unit **401***a*, an address block storage unit **404**, a router function unit **405**, an address allocation unit **406**, a wireless communication unit **407**, and a TE connection wireless communication unit **408**. Elements in this drawing that correspond with elements in FIG. **7** are assigned the same reference numerals, and the description thereof is omitted. The connection request unit **401***a* has an attach request unit **402***a*. The attach request unit **402***a*, when sending an Attach Request to the core network **20** via the ENB device **31**, includes a request for PDN connection setup. By this request, the attach request unit **402***a* receives from the core network **20**, via the ENB device **31**, the IP address and information indicating the address block allocated to the PDN connection for the TE (IPv4 network address or IPv6 prefix).

FIG. **13** is a drawing showing an example of the sequence of attaching the mobile terminal device **40***a* to the EPS in the present embodiment. Because from sequence S**1401** to S**1407** is the same as from sequence S**901** to S**907** in the first embodiment (FIG. **9**), the description thereof will be omitted. After completion of S**1407**, the MME device **22** transmits a Bearer Setup Request to the S-GW device **23** for the purpose of establishing a default EPS bearer (S**1408**). In order to simultaneously establish the PDN connection **1** for the UE and the PDN connection **2** for the TE, this Bearer Setup Request includes, in addition to the subscriber identification information and the IP address of the PDN-GW device **21**, the APN, the PDN connection ID**1**, the PDN type **1**, the PDN address **1**, and the EPS bearer ID**1** for establishing the PDN connection **1** for the UE, and the APN, the PDN connection ID**2**, the MNP type **1**, MNP, and EPS bearer ID**2** for establishing the PDN connection **2** for the TE. In the case in which the PDN connection ID is an identifier that is independent from the APN, one APN only may be included.

The S-GW device **23** receives the Bearer Setup Request, and starts the procedure for establishing the default EPS bearer with the PDN-GW device **21**. In the case in which GTP is used between the S-GW device **23** and the PDN-GW device **21**, the S-GW device **23** transmits a Bearer Setup Request to the PDN-GW device **21** (S**1409**). This Bearer Setup Request includes the subscriber identification information, the IP address of the S-GW device **23**, the APN and PDN connection ID**1**, the TEID**1** for the S-GW, the PDN type **1**, the PDN address **1**, the EPD bearer ID**1**, the APN and PDN connection ID**2**, the TEID**2** for the S-GW, the MNP type **1**, MNP**1**, and the EPS bearer ID**2**.

In the case in which GRE is used between the S-GW device **23** and the PDN-GW device **21**, at the sequence S**1409**, the S-GW device **23** transmits to the PDN-GW device **21** a Proxy Binding Update message. The Proxy Binding Update message includes the mobile communication network access identifier, the APN and PDN connection ID**1**, the downlink GRE key **1**, the PDN type **1**, the PDN address **1**, and the EPS bearer ID**1**, and the APN and PDN connection ID**2**, the downlink GRE key **2**, the MNP type **1**, MNP**1**, and the EPS bearer ID**2**.

The PDN-GW device **21** receives the Bearer Setup Request or Proxy Binding Update of the sequence S**1409**, and starts the setup of the PDN connection **1** and the PDN connection **2** (S**1410** and S**1411**). The PDN connection **1** setup method of the sequence S**1410** is in accordance with S**910** of the first embodiment. The PDN connection **2** setup method of the sequence S**1411** is in accordance with S**1006** of the first embodiment.

When the setup of the PDN connection **1** and the setup of the PDN connection **2** are completed, the PDN-GW device **21** returns a Bearer Setup Response or a Proxy Binding Acknowledgment to the S-GW device **23** (S**1412**). In the case in which GTP is used, the Bearer Setup Response is used in the sequence S**1412**, and the Bearer Setup Response includes the TEID**1** for the PDN-GW, the PDN type **1**, the PDN address **1**, and the EPS bearer ID**1** for the PDN connection **1**, and the TEID**2** for the PDN-GW, the MNP type **1**, MNP**1**, and the EPS bearer ID**2** for the PDN connection **2**.

In the case in which GRE is used, the Proxy Binding Acknowledgment is used, and the Proxy Binding Acknowledgment includes the mobile network access identifier, the PDN connection ID**1**, the uplink GRE key **1**, the PDN type **1**, the PDN address **1**, the PDN connection ID**2**, the uplink GRE key **2**, the MNP type **1**, and MNP**1**.

Additionally, the PDN-GW device **21** begins transfer up to the S-GW device **23** of a user packet addressed to the PDN address **1** from the external PDN **50**, using the established EPS bearer **1**. Also, transfer up to the S-GW device **23** of the user packet addressed to MNP**1** from the external PDN **50** begins, using the established EPS bearer **2** (S**1413**).

When the Proxy Binding Acknowledgment or the Bearer Setup Response of the sequence S**1412** is received, the S-GW device **23** associates and records in a management table (PDN connection holding unit **231**) the PDN address **1**, MNP**1**, the subscriber identification information, and the MME device **22**, and also transmits the Bearer Setup Response to the MME device **22** (S**1414**). The Bearer Setup Response includes the IP address of the S-GW device **23**, the TEID**1** for the S-GW, the PDN type **1**, the PDN address **1**, and the EPS bearer ID**1** for PDN connection **1**, and the TEID**2** for the S-GW, the MNP type **1**, MNP**1** and the EPS bearer ID**2** for PDN connection **2**. The S-GW device **23** begins buffering the user packets transferred from the PDN-GW device **21** addressed to the PDN address **1** and addressed to MNP**1** (S**1413**).

The MME device **22** receives the Bearer Setup Response, and transmits an Attach Accept to the ENB device **31** (S**1415**). The Attach Accept includes the IP address of the S-GW device **23**, the APN, the PDN connection ID**1**, the TEID**1** for the S-GW, the PDN type **1**, the PDN address **1**, and the EPS bearer ID**1** for the PDN connection **1**, and the APN, the PDN connection ID**2**, the TEID**2** for the S-GW, the MNP type **1**, MNP**1**, and the EPS bearer ID**2** for the PDN connection **2**.

The ENB device **31** transmits to the mobile terminal device **40***a* an Attach Accept that includes the APN, the PDN connection ID**1**, the PDN type **1**, the PDN address **1**, and the EPS bearer ID**1** for the PDN connection **1**, and the APN, the PDN connection ID**2**, the MNP type **1**, MNP**1**, and the EPS bearer ID**2** for the PDN connection **2** (S**1416**). The mobile terminal device **40***a* receives the Attach Accept, acquires the PDN type **1**, the PDN address **1**, the MNP type **1**, and MNP**1** included therein, and transmits to the ENB device **31** an Attach Complete that includes the EPS bearer ID**1** and the EPS bearer ID**2** (S**1417**). The mobile terminal device **40***a* also transitions to the state in which user data can be transmitted and received.

The ENB device **31** receives the Attach Complete, and transmits to the MME device **22** an Attach Complete that includes the IF address of the ENB device **31**, the TEID**1** for the ENB, the EPS bearer ID**1**, the TEID**2** for the ENB, and the EPS bearer ID**2** (S**1418**).

At this point, when the mobile terminal device **40***a* transmits user data addressed to the external PDN **50**, after the user data is transferred up to the PDN-GW device **21**, using the EPS bearer **1** within the established PDN connection **1**, it is sent to the external PDN **50** (S**1419**).

When the Attach Complete of the sequence S**1418** is received, the MME device **22** transmits to the S-GW device **23** a Bearer Setup Request that includes the IP address of the ENB device **31**, TEID**1** for the ENB, the EPS bearer ID**1**, TEID**2** for the ENB, and the EPS bearer ID**2** (S**1420**). The S-GW device **23** returns to the MME device **22** a Bearer Update Response that includes the EPS bearer ID**1** and the EPS bearer ID**2** (S**1421**).

The S-GW device **23** that has received the Bearer Update Request of sequence S**1420** acquires the IP address of the ENB device **31** to which the mobile terminal device **40***a* is connected from the Bearer Update Request, and begins to transfer to the ENB device **31***a* user packet transferred from the PDN-GW device **21** to the mobile terminal device **40***a* and to the TE device **41***a* (addressed to MNP**1**) that had been buffered, and the ENB device **31** transmits that user packet to the mobile terminal device **40***a* (S**1422**).

The mobile terminal device **40***a* that transmitted the Attach Complete at sequence S**1417** to the ENB device **31** begins the allocation (Router Advertise transmission) of the IP address to the TE device **41***a*, using the IPv4 sub-network address **2** and the IPv6 prefix **2** set into the MNP**1** of the Attach Accept in the sequence S**1416** (S**1423**).

The MME device **22**, after receiving the Bearer Update Request of sequence S**1421**, transmits a Location Information Update Request to the HSS device **24** (S**1424**). This Location Information Update Request includes information of the established PDN connection **1** and PDN connection **2**, which includes the address of the PDN-GW device **21**, the APN, the PDN connection ID**1**, the PDN type **1**, and the PDN address **1** as PDN connection **1** information, and the APN, the PDN connection ID**2**, the MNP type **1**, and MNP**1** as the PDN connection **2** information. The HSS device **24** stores this information into the subscriber's subscription data, and when the power to the mobile terminal device **40***a* is turned on or off, or the like, so that the mobile terminal device **40***a* attaches once again to the EPS, the same MNP**1** is allocated. The HSS device **24** also transmits a Location Information Update Acknowledgment (Update Location Ack) to the MME device **22** (S**1425**).

The above completes the simultaneous attach of the mobile terminal device **40***a* to the EPS and the establishment of the PDN connection **2** for the TE. Although in this example there are two PDN connections that are established simultaneously, two is not a limitation, and the same type of method can be used to simultaneously three or more PDN connections.

In this manner, even at the stage at which the TE has not been started, by establishing a PDN connection for the TE simultaneously with the attach of the mobile terminal device **40***a* to the EPS, it is possible to combine the establishment of a plurality of PDN connections into a single signaling, thereby reducing the number of signaling messages in the overall system, and shortening the time required to establish all the PDN connections. Also, after the TE is started, it is possible to establish connectivity to the external PDN **50** immediately.

## Third Embodiment

The third embodiment of the present invention is described below, with references made to drawings. The mobile communication system **10***b* in the present embodiment has a configuration similar to that of the mobile communication system **10** of the first embodiment, although it differs in that, in place of the PDN-GW device **21**, it is provided with a PDN-GW device **21***b*, and that, in place of the mobile terminal device **40**, it is provided with a mobile terminal device **40***b*. By doing this, in contrast to the first embodiment, in which a NAS signaling message set forth in the 3GPP standard is used to allocate an address block to the UE, in the present embodiment the DHCP (Dynamic Host Configuration Protocol) v6 Prefix Delegation (IETF RFC 3633) is used to allocate an address block to the UE.

FIG. **14** is a simplified block diagram showing the configuration of the PDN-GW device **21***b* in the present embodiment. The PDN-GW device **21***b* in the present embodiment, is the PDN-GW device **21** shown in FIG. **2** with the addition of a DHCP server unit **217**. The DHCP server unit **217**, upon receiving an address block request using the DHCP, allocates an address block to the PDN connection for the TE of the mobile terminal device **40***b* originating the request, and send this to the mobile terminal device **40***b*. In the case in which GRE is used as the tunneling protocol for implementing an EPS bearer between the S-GW device **23** and the PDN-GW device **21***b*, the S-GW device **23** has a DHCP relay function (not shown).

FIG. **15** is a simplified block diagram showing the configuration of the mobile terminal device **40***b* in the present embodiment. The mobile terminal device **40***b* in the present embodiment is the mobile terminal device **21** with the addition of a DHCP client unit **409**. The DHCP client unit **409** uses a dynamic host setup protocol to request an address block from the PDN-GW device **21***b*, and receives from the PDN-GW device **21***b* information that indicates the address block allocated to the PDN connection for the TE by the request.

FIG. **16** is a sequence diagram showing an example of the connection sequence of the mobile terminal device **40***b* in the present embodiment. The sequence shown in FIG. **16** is a sequence that is started by the mobile terminal device **40***b* after the sequence S**1012** of FIG. **10**. The mobile terminal device **40***b*, after transmitting to the ENB device **31** an RRC Connection Reconfiguration Complete of sequence S**1012**, rather than using MNP**1** that is acquired at sequence S**1011**, starts the DHCP sequence indicated below for acquiring the address block anew.

The DHCP client **409** of the mobile terminal device **40***b* first, to find the DHCP server, transmits a DHCP Solicit message by a link-local broadcast transmission (S**1101**). In the case in which GRE is used between the S-GW device **23** and the PDN-GW device **21***b*, because the S-GW device **23** functions as the default router of the mobile terminal device **40***b*, the S-GW device **23** receives the DHCP Solicit message and transfers it to the PDN-GW device **21***b*, using the DHCP relay function. In the case in which GTP is used, because the PDN-GW device **21***b* functions as the default router, the DHCP Solicit message transmitted by the mobile terminal device **40***b* reaches the PDN-GW device **21***b* directly.

The DHCP server unit **217** provided in the PDN-GW device **21***b* receives the DHCP Solicit message and transmits a DHCP Advertise message that stores the IP address of the DHCP server unit **217** (S**1102**). In the case in which GRE is used, in the same manner the DHCP relay function in the S-GW device **23** transfers the DHCP Advertise message to the mobile terminal device **40***b*. When the DHCP client unit **409** of the mobile terminal device **40***b* receives the DHCP Advertise message and acquires the IP address of the DHCP server unit **217** of the PDN-GW device **21***b*, a DHCP Request message in which is stored the IPv6 prefix length (in this case 48) for which allocation is desired is transmitted to the DHCP server unit **217** of the PDN-GW device **21***b* (S**1103**).

The DHC server unit **217** of the PDN-GW device **21***b* receives the DHCP Request message from the mobile terminal device **40***b* and extracts the IPv6 prefix **3**, which corresponds to the requested prefix length (provisionally 2001:1000::/48) from the address pool stored by the address block holding unit **214** of the corresponding device and assigns it to the PDN connection **2**. Additionally, the MNP**1** that was assigned to the PDN connection **2** at sequence S**1006** is released and returned to the address pool that is managed by the PDN-GW device **21***b*, the new IPv6 prefix **3** is allocated to MNP**1**, and the setting is made so that a user packet directed at the IPv6 prefix **3** from the external PDN **50** is linked to the EPS bearer **2**, and transferred up to the S-GW device **23** (S**1104**).

Then, the DHCP server unit **217** of the PDN-GW device **21***b* stores the IPv6 prefix **3** in the DHCP Reply message, and transmits it to the mobile terminal device **40***b* (S**1105**). In the case in which GRE is used, because the S-GW device **23** receives the DHCP Reply message, similar to the case of the PDN-GW device **21***b*, the MNP**1** that had been allocated to the PDN connection **2** is updated and the IPv6 prefix **3** is allocated, and the DHCP Reply message is transferred to the mobile terminal device **40***b*.

The DHCP client unit **409** of the mobile terminal device **40***b* acquires the DHCP Reply message and, using the allocated IPv6 prefix **3**, allocates an address to the mobile terminal device **40***b*, similar to sequences S**1017** and S**1018** of the first embodiment (FIG. **10**).

Although this description is for the example in which IPv6 is selected as the MNP type, the same would apply if the MNP type were to be IPv4.

In this manner, by acquiring the IPv6 prefix or the IPv4 sub-network prefix by DHCP, it is possible to freely set the prefix length, and to acquire the required number of address blocks by one procedure, further enabling the combination of all communication that uses an IP address generated from the address blocks into one PDN connection.

## Fourth Embodiment

The fourth embodiment of the present invention is described below, with references made to drawings. The mobile communication system **10** in the present embodiment is a configuration similar to that of the mobile communication system **10** of the first embodiment, although it differs in that, in place of the PDW-GW device **21**, it is provided with a PDN-GW device **21***c*, and that, in place of the mobile terminal device **40**, it is provided with a mobile terminal device **40***c*. By doing this, in contrast to the first embodiment, in which one IPv4 sub-network address or one IPv6 prefix or both are assigned to a plurality of TEs and the plurality of TEs share one PDN connection, in the present embodiment while an IPv6 prefix is shared by a plurality of TEs, different PDN connections are used for each TE.

FIG. **17** is a simplified block diagram showing the configuration of the PDN-GW device **21***c*. The PDN-GW device **21***c* has an address block holding unit **211**, a PDN connection setup unit **212***c*, an S-GW connection interface unit **213**, a PDN connection holding unit **214**, a user data transfer unit **215**, and a PDN connection interface unit **216**. The descriptions of reference numerals in this drawing that are the same as in FIG. **2** (**211** and **213** to **216**) have been omitted. The PDN connection setup unit **212***c* performs the same type of setup of the PDN connection for the UE as the PDN connection setup unit **212**. However, the PDN connection setup unit **212***c*, upon receiving a request for the setup of a PDN connection for the TE from the mobile terminal device **40***c*, associates an address belonging to the address block allocated to the PDN connection for the TE with information regarding the PDN connection for the TE, causes the PDN connection holding unit **214** to store these, and transmits the allocated address to the mobile terminal device **40***c*.

FIG. **18** is a simplified block diagram showing the configuration of the mobile terminal device **40***c*. The mobile terminal device **40***c* has a connection request unit **401***c*, an address block storage unit **404**, a router function unit **405**, an address allocation unit **406***c*, a wireless communication unit **407**, and a TE connection wireless communication unit **408**. The connection request unit **401***c* has an attach request unit **402** and a TE connection request unit **403***c*. The descriptions of reference numerals in this drawing that are the same as in FIG. **7** (**402**, **404**, **405**, **407**, and **408**) have been omitted. The TE connection request unit **403***c*, upon receiving a connection request from the TE devices **41***a* and **41***b*, request the core network **20** to setup a TE PDN connection, and receives as a response to the request information that indicates the address that was allocated to the PDN connection for the TE. The TE connection request unit **403***c* causes the received address to be stored in the address block storage unit **404**. The address allocation unit **406***c* allocates the address stored in the address block storage unit **404**, that is, the address received by the PDN connection request unit **403***c* to the TE devices **41***a* and **41***b*.

FIG. **19** is a sequence diagram showing an example of the sequence of the connection for the TE devices **41***a* and **41***b* performing communication with an external PDN **50**. In this sequence example, the sequence starts from the condition in which the sequence shown in FIG. **9** of attachment of the mobile terminal device **40***c* to the EPS in the first embodiment has already been completed. First, the TE device **41***a* places the MT connection wireless communication unit **412** in the active state, the IP address is allocated and the protocol is started. This description is for the case in which IPv6 Stateless Auto Configuration is sued as the IP address allocation protocol.

The TE device **41***a*, in order to search for the default router, transmits a Router Solicit (S**1201**). The mobile terminal device **40***e* receives the Router Solicit from the TE device **41***a* and if the mobile terminal device **40***c* itself has transitioned to the idle state within the EPS, transitions to the active state in order to transmit and receive communication data (S**1202**) (refer to TS 23.401, the 3GPP specifications). The lower-order 64 bits of the link-local address that was the origin of the

Router Solicit (automatically generated by the TE device **41***a*, using the MAC address of the MT connection wireless communication unit **412**) is held as the interface ID**1** of the TE device **41**.

Then, in order to establish the PDN connection **2** anew for the TE device **41***a*, a PDN Connectivity Request is transmitted to the MME device **22** (S**1203**). This PDN Connectivity Request includes the APN, the MNP type **1**, and the interface ID**1** of the TE device **41** acquired as noted above. The MME device **22** receives the PDN Connectivity Request and, to establish a PDN connection anew, transmits a Bearer Setup Request to the S-GW device **23** (S**1204**).

The Bearer Setup Request includes, in addition to the APN and MNP type **1** included in the PDN Connectivity Request of sequence S**1203**, the subscriber identification information, the IP address of the PDN-GW device **21***c*, the PDN connection ID**2**, MNP**1**, the interface ID**1**, and the EPS bearer ID**2**. The MNP and the interface ID may not be independent data elements. For example, the upper-order 64 bits of one information element may be used as the upper-order 64 bits of the MNP, and the lower-order 64 bits may be used as the interface ID.

The S-GW device **23** receives the Bearer Setup Request and begins the procedure for establishing the default EPS bearer for the TE device **41***a* with the PDN-GW device **21***c*. In the case in which GTP is used as the protocol for implementing the EPS bearer, the S-GW device **23** transmits the Bearer Setup Request to the PDN-GW device **21***c* (S**1205**). The Bearer Setup Request includes the subscriber identification information, the IP address of the S-GW device **23**, the APN, the PDN connection ID**2**, the TEID**2** for the S-GW, the MNP type **1**, MNP**1**, the interface ID**1**, and the EPS bearer ID**2**.

In the case in which GRE is used as the protocol for implementing the EPS bearer, the S-GW device **23** transmits a Proxy Binding Update message to the PDN-GW device **21***c*. The Proxy Binding Update message includes the mobile network access identifier, the APN, the PDN connection ID**2**, the downlink GRE key **2**, the MNP type **1**, MNP**1**, and the interface ID**1**.

The PDN-GW device **21***c* receives the Bearer Setup Request of the sequence S**1205** and starts the setup of the PDN connection **2** (S**1206**). First, in the case in which a specific IPv4 sub-network address and a specific IPv6 prefix are not specified in the MNP**1**, the PDN-GW device **21***c* allocates the IPv6 prefix **2** to the MNP**1**, from the address block pool managed by the PDN-GW device **21***c*, according to the MNP type **1**. Then, the upper-order 64 bits of MNP**1** are allocated to the upper-order 64 bits, and a new IPv6 address **2** to which the interface ID is allocated is generated, and the IPv6 address **2**, as the PDN address of the established PDN connection **2**, is allocated to the lower-order 64 bits. Additionally a default EPS bearer that is associated with the PDN connection **2** is established, and a user packet addressed to the IPv6 address **2** from the PDN is linked to the above-noted EPS bearer **2**.

Then, the PDN-GW device **21***c* returns a Bearer Setup Response or a Proxy Binding Acknowledgment to the S-GW device **23** (S**1207**). In the case in which GTP is used, the Bearer Setup Response is used in the sequence S**1207**. This Bearer Setup Response includes the TEID**2** for the PDN-GW, the PDN type **2**, the PDN address **2**, and the EPS bearer ID**2**. For the PDN type **2**, the IPv6 address **2** is stored in the PDN address **2** as the address type of the ID address allocated to the PDN connection **2**. In the case in which GRE is used, the Proxy Binding Acknowledgment is used in the sequence S**1207**. This Proxy Binding Acknowledgment includes the mobile network access identifier, the PDN connection ID**2**, the uplink GRE key **2**, the PDN type **2**, and the PDN address **2**.

Additionally, the PDN-GW device **21***c*, using the EPS bearer **2**, starts the transfer up to the S-GW device **23** of user packets from the external PDN **50** addressed to the IPv6 address (S**1208**).

Upon receiving the Bearer Setup Response or the Proxy Binding Acknowledgment of sequence S**1207**, the S-GW device **23** associates the PDN address **2**, the subscriber identification information, and the MME device **22** and records these in a management table (PDN connection holding unit **231**), and also transmits the Bearer Setup Response to the MME device **22** (S**1209**). The Bearer Setup Response includes the IP address of the S-GW device **23**, the TEID**2** for the S-GW, the PDN type **2**, the PDN address **2**, and the EPS bearer ID**2**. The S-GW device **23** also starts buffering of user packets transferred from the PDN-GW device **21***c*.

The MME device **22** receives the Bearer Setup Response and sends a PDN Connectivity Accept to the ENB device **31** (S**1210**). The PDN Connectivity Accept includes the address of the S-GW device **23**, the APN, the PDN connection ID**2**, the TEID**2** for the S-GW, the PDN type **2**, the PDN address **2**, and the EPS bearer ID**2**. The ENB device **31**, upon receiving the PDN Connectivity Accept in the sequence S**1210**, transmits to the mobile terminal device **40***c* a PDN Connectivity Accept that includes the APN, the PDN connection ID**2**, the PDN type **2**, the PDN address **2**, and the EPS bearer ID**2** (S**1211**).

The mobile terminal device **40***c* receives this PDN Connectivity Accept, acquires the PDN address **2**, and also transmits to the ENB device **31** an RRC Connection Reconfiguration Complete that includes the EPS bearer ID**2** (S**1212**). Because the subsequent sequences S**1213**, S**1214**, S**1215**, and S**1216** are the same as the sequences S**1013**, S**1014**, S**1015**, and S**1016** in the first embodiment, their descriptions have been omitted.

The mobile terminal device **40***c* that transmitted the RRC Connection Reconfiguration Complete at sequence S**1212**, extracts the IPv6 address **2** from the acquired PDN address **2**, and transmits to the TE device **41***a* a Router Advertisement in which the 64 upper-order bits thereof are set as the IPv6 prefix (S**1217**). This Router Advertisement is a response to the Router Solicit of sequence S**1201**.

The TE device **41***a* receives the Router Advertisement and performs automatic generation of the IPv6 address, using the IPv6 prefix included in the Router Advertisement and the interface ID, and as a result the same address as the IPv6 address **2** is generated. Additionally, the TE device **41***a* executes DAD (Duplicate Address Detection) with the mobile terminal device **40***c* (S**1218**), and verifies that the generated IPv6 address is unique (S**1218**).

The TE device **41***a*, having verified by Duplicate Address Detection that the IPv6 address is unique, is able to transmit and receive user packets via the MT connection wireless communication unit **412**. User packets addressed to the IPv6 address from the PDN-GW device **21***c* are transferred up to the mobile terminal device **40***c* via the S-GW device **23** and the ENB device **31**, and the mobile terminal device **40***c* transfers them to the TE device **41***a* via the TE connection wireless communication unit **408** (S**1219**).

When the mobile terminal device **40***c* receives a user packet from the TE device **41***a*, the router function of the mobile terminal device **40***c* routes it in accordance with the transmission destination address of the user data. In the case in which the transmission destination address is MNP**1** or the mobile terminal device **40***c* itself, the mobile terminal device

40$c$ transfers it directly to the addressee. For any other transmission destination address, the user data is transferred to the EPS bearer **2** within the established PDN connection **2**, the user data is transferred to the EPS bearer within the established PDN connection **2**, and is transferred up to the PDN-GW device **21**$c$ and transmitted to the external PDN **50** by the PDN-GW device **21**$c$ (S**1220**).

The MME device **22**, after receiving the Bearer Update Response of the sequence S**1215**, transfers the Location Information Update Request to the HDD device **24** (S**1221**). The Location Information Update Request includes information of the established PDN connection **2**, and includes the APN, the PDN connection ID**2**, the IP address of the PDN-GW device **21**$c$, the MNP type **1**, and MNP**1**.

The HSS device **24**, stores this information in the subscriber's subscription data so that when the mobile terminal device **40** re-attaches to the EPS (when, for example, the power is switched on/off) and performs a PDN Connectivity Request, the same PDN address prefix is allocated. The HSS device **24** also transmits the Location Information Update Request to the MME device **22** (S**1222**).

After the above, when a TE device **41**$b$ is connected to the mobile terminal device **40**$c$, the sequences S**1201** to S**1222** are repeated, and a new PDN connection is established. However, the MIME device **22** stores into MNP**1** within the Bearer Setup Request transmitted to S-GW device **23** the IPv6 prefix already allocated to the TE device **41**$a$, so that an IP address having the same IPv6 prefix is assigned to the TE device **41**$b$ as well. This process is applied to the all TEs subsequent to the second TE.

Although the present embodiment has been described for the example in which IP6V is used, the same type of processing is done in the case of using IPv4. In the case of IPv4, however, the interface ID is not used, and at sequence S**1206** the PDN-GW device **21**$c$ generates an IPv4 address for the TE from one IPv4 sub-network address, and allocates this as the PDN address **2**.

In this manner, by the TE devices **41**$a$ and **41**$b$ and the like establishing PDN connections for each TE, and PDN-GW device **21**$c$ or mobile terminal device **40**$c$ making assignment to separate EPS bearers for each TE IP address, even for one and the same communication party, it is possible to allocate different QoS classes and charging rules for each TE individually.

## Fifth Embodiment

In the first to fourth embodiments, the IPv6 prefix allocated to the plurality of TEs and the IPv6 prefix allocated to the mobile terminal device **40** are different. In the mobile communication system **10**$d$ of the fifth embodiment of the present invention, the configuration is similar to that of the mobile communication system **10**$c$ of the fourth embodiment, the only difference being that, in place of the MME device **22**, an MME device **22**$d$ is provided. By doing this, in this embodiment the same prefix is shared among the mobile terminal device **40** and the plurality of TEs.

FIG. **20** is a simplified block diagram showing the configuration of the MME device **22**$d$ in the present embodiment. The MME device **22**$d$ has an HSS connection interface **221**, a communication control unit **222**$d$, an ENODEB connection interface **223**, a location information holding unit **224**, a subscriber information holding unit **225**, and an S-GW connection interface **226**. The communication control unit **222**$d$ has a setting enabled/disabled judgment unit **227**. In this drawing, parts that are the same as in FIG. **4** are assigned the same reference numerals (**221** and **223** to **227**) and are not described herein. The only difference is that the communication control unit **222**$d$ differs from the communication control unit **222** in FIG. **4**. In the following, only those parts in the present embodiment of the sequence that differ from that shown in FIG. **19** are described.

In the present embodiment, the communication control unit **222**$d$ of the MME device **22**$d$ that has received a PDN Connectivity Request in sequence S**1203** extracts from within the subscription data the IPv6 prefix **1** assigned to the mobile terminal device **40**. The MME device **22**$d$ then stores that value in MNP**1** and transmits a Bearer Setup Request to the S-GW device **23** (S**1204**).

By doing this, in the sequence S**1206**, the PDN-GW device **21**$c$ allocates the MNP**1** specified by the Bearer Setup Request, that is, allocates the PDN address that uses the IPv6 prefix allocated to the mobile terminal device **40** to the PDN connection **2**. As a result, the same IPv6 prefix is allocated to the TE device **41**$a$ as is allocated to the mobile terminal device **40**. Thereafter, even if a different TE connects to the mobile terminal device **40**, the same type of processing is repeated. Therefore, IPv6 address that different only in the lower-order 64 bits are assigned to the mobile terminal device **40** and to the TE that connects to the mobile terminal device **40**, enabling effective use of the address space for IPv6 addresses.

## Sixth Embodiment

The sixth embodiment of the present invention is described below, with references made to drawings. The mobile communication system **10**$e$ in this embodiment has a configuration that is similar to the mobile communication system **10** in the first embodiment, and the only different is that, in place of the mobile terminal device **40**, a mobile terminal device **403** is provided. By doing this, in contrast to starting the sequence for establishing the PDC connectivity, in the present embodiment PDN connectivity is established simultaneously with transmitting a packet to the external PDN **50**.

FIG. **21** is a simplified block diagram showing the configuration of the mobile terminal device **40**$e$. The mobile terminal device **40**$e$ has a connection request unit **401**$e$, an address block storage unit **404**, a router function unit **405**, an address allocation unit **406**, a wireless communication unit **407**, and a TE connection wireless communication unit **408**. The connection request unit **401**$e$ has an attach request unit **402** and a TE connection request unit **403**$e$. In this drawing, parts that are the same as in FIG. **7** are assigned the same reference numerals (**402** and **404** to **408**) and are not described herein. When the addressee of the user data received from the TE devices **41**$a$ and **41**$b$ is the external PDN **50**, the TE connection request unit **403**$e$ makes a request of the core network **20** to setup a TE PDN connection, and receives from the core network **20** information indicating the address block allocated to the TE PDN connection setup by this request.

FIG. **22** is a drawing showing an example of the connection sequence for performing communication by the TE device **41**$a$ with the external PDN **50**. This connection sequence example is the example of the sequence that starts from the condition in which the EPS attach sequence of the mobile terminal device **40** in the first embodiment shown in FIG. **9** has been completed. The mobile terminal device **40**$e$ stores in its own management information area beforehand the MNP**1** for allocation to the TE. The method used may be that of storing a past setting, and alternatively can be the method of downloading from the core network **20** at the time of the EPS attach sequence of the mobile terminal device **40**$e$.

First, the mobile terminal device **40**$e$ receives a Router Solicitation from the TE device **41**$a$ (S**1301**). The mobile terminal device **40***e* extracts the IPv6 prefix **2** from the MNP**1** stored in the management information area and transmits the Router Advertisement that stores this to the TE device **41***a* (S**1302**). The TE device **41***a* generates an IPv6 address in accordance with the received Router Advertisement, and performs Duplicate Address Detection (DAD) of the generated IPv6 address with the mobile terminal device **40** (S**1303**).

For the case in which the mobile terminal device **40***e* receives a Router Solicitation from the TE device **41***b* as well, in the same manner, a Router Advertisement in which the IPv6 prefix **2** is stored is transmitted to the TE device **41***b* (S**1305**) and address generation of the IPv6 address and the Duplicate Address Detection are performed based on the Router Advertisement received from the TE device **41***b* (S**1306**).

When the TE device **41***a* receives user data via the MT connection wireless communication unit **412** (S**1307**), the mobile terminal device **40***e* receives that user data and verifies the transmission destination address of the user data. If the transmission destination address is MNP**1** or the mobile terminal device **40***e* itself, rather than establishing a new PDN connection, the user data is transmitted to the transmission destination node (S**1308**).

If the transmission destination address does not coincide with the above (S**1309**), the mobile terminal device **40***e* judges that the user data is communication data directed to the external PDN **50**, and performs establishment of a new PDN connection. The establishment of this PDN connection is done by performing the same processing as sequences S**1002** to S**1015** in the first embodiment shown in FIG. **10**. After the PDN connection is established, user data transferred to the TE device **41** from the PDN-GW device **21** is transferred up to the mobile terminal device **40***e*, via the S-GW device **23** and the ENB device **31** (sequence S**1016** in FIG. **10**), and the mobile terminal device **40***e* transfers this user data to the TE device **41***a* (S**1310**). In contrast, user data that the TE device **41** transmits to the external PDN **50**, is transferred up to the PDN-GW device **21**, and the PDN-GW device **21** transmits it to the external PDN **50** (S**1311**).

The MME device **22**, after receiving a Bearer Update Response in sequence S**1015**, transmits a location information update request to the HSS device **24** (S**1312**). This Location Information Update Request includes the information of the established PDN connection **2**, the APN, the PDN connection ID**2**, address of the PDN-GW, the MNP type **1**, and MNP**1**. The HSS device **24** stores this information in the subscriber's subscription data, so that when the mobile terminal device **40***e* again attaches to the EPS and makes a PDN Connectivity Request, such as when power to the mobile terminal device **40***e* is switch on/off, the same MNP**1** is allocated. The HSS device **24** also transmits the Location Information Update Request to the MME device **22** (S**1313**).

When the PDD Connectivity Request in sequence S**1011** is received, if the MNP**1** extracted by the mobile terminal device **40***e* from the PDN Connectivity Accept for the TE does not coincide with the MNP**1** held in the management information area by the mobile terminal device **40***e*, the mobile terminal device **40***e* transmits to the TE device **41***a* and the TE device **41***b* a Router Advertisement using the MNP**1** acquired from the PDN Connectivity Accept. Additionally, the Router Advertisement using the MNP**1** that was held in the management information area is transmitted with zero lifetime set, so as to prompt communication by only the IP address generated by the TE device **41***a* and TE device **41***b* from the MNP**1**.

In this manner, in the present embodiment, because a PDN connection is first established when communication to the external PDN **50** occurs, as long as the TE and mobile terminal device **40***e* are only communicating locally, it is not necessary to consume the resources of the core network **20** and the wireless access network **30**.

A program that implements the functions of the PDN connection setting unit **212**, and the user data transfer unit **215** in FIG. **2**; the user data transfer unit **232** and the communication control unit **235** in FIG. **3**; the communication control unit **222** in FIG. **4**; the control unit **242** in FIG. **5** and the communication control unit **312** in FIG. **6**; the connection request unit **401**, the router function unit **405**, and the address allocation unit **406** in FIG. **7** and the control unit **411** in FIG. **8**; the connection request unit **401***a*, the router function unit **405**, and the address allocation unit **406** in FIG. **12**; the PDN connection setting unit **212**, the user data transfer unit **215**, and the DHCP server unit **217** in FIG. **14**; the connection request unit **401**, the router function unit **405**, the address allocation unit **406**, and the DHCP client unit **409** in FIG. **15**; the PDN connection setting unit **212***c* and the user data transfer unit **215** in FIG. **17**; the connection request unit **401***c*, the router function unit **405**, and the address allocation unit **406** in FIG. **18**, the communication control unit **222***d* in FIG. **20**; and the connection request unit **401***e*, the router function unit **405**, and the address allocation unit **406** in FIG. **21** may be stored in a computer-readable storage medium and the program stored in the medium read into a computer system and executed thereby so as to execute the processing of the various elements. The term "computer system" as used herein encompasses an operating system and hardware such as peripheral devices.

If the "computer system" uses the WWW system, it encompasses a webpage providing (or display) environment.

The "computer-readable storage medium" refers to removable media such as a flexible disk, an optomagnetic disk, a ROM, or a CD-ROM, and also to storage devices such as a hard-disk that are built into the computer system. The "computer-readable storage medium" also includes the short-term, dynamic holding of a program, such as in the case of transmitting a program via a network such as the Internet or via a communication line such as a telephone line, in which case the program is held for a given period of time, such as in a volatile memory within a server and client that serve as the computer system. The above-noted program may be for the purpose of implementing a part of the above-described functions, and the above-described functions may be implemented in combination with a program that is already stored in the computer system.

Although embodiments of the present invention are described above with reference made to the drawings, the actual configuration is not restricted to these embodiments, and encompasses changes in design that are within the scope of the spirit of the present invention.

## INDUSTRIAL APPLICABILITY

The present invention is suitable for use in a mobile communication system but is not restricted to such use.

## REFERENCE SYMBOLS

**10**: Mobile communication system
**20**: Core network
**21**, **21***b*, **21***c*: PDN-GW device
**22**, **22***d*: MME device
**23**: S-GW device
**24**: HSS device
**30**: Wireless access network

**31**: ENB device
**40**, **40***a*, **40***b*, **40***c*, **40***e*: Mobile terminal device
**41***a*, **41***b*: TE device
**50**: External PDN
**211**: Address block holding unit
**212**, **212***c*: PDN connection setting unit
**213**: S-GW connection interface unit
**214**: PDN connection holding unit
**215**: User data transfer unit
**216**: PDN connection interface unit
**217**: DHCP server unit
**221**: HSS connection interface unit
**222**, **222***d*: Communication control unit
**223**: ENODEB connection interface unit
**224**: Location information holding unit
**225**: Subscriber information holding unit
**226**: S-GW connection interface unit
**227**: Setting enabled/disabled judgment unit
**231**: PDN connection holding unit
**232**: User data transfer unit
**233**: ENODEB connection interface unit
**234**: PDN-GW connection interface unit
**235**: Communication control unit
**236**: MME connection interface unit
**241**: MME connection interface unit
**242**: Control unit
**243**: Location information holding unit
**244**: Subscriber information holding unit
**311**: Wireless communication unit
**312**: Communication control unit
**313**: S-GW connection interface unit
**314**: MME connection interface unit
**401**, **401***a*, **401***c*, **401***e*: Connection request unit
**402**, **402***a*: Attach request unit
**403**, **403***c*, **403***e*: TE connection request unit
**404**: Address block storage unit
**405**: Router function unit
**406**, **406***c*: Address allocation unit
**407**: Wireless communication unit
**408**: TE connection wireless communication unit
**409**: DHCP client unit
**411**: Control unit
**412**: MT connection wireless communication unit

The invention claimed is:

**1**. A mobile terminal device in a mobile communication system comprising at least one information terminal device, the mobile terminal device, and an external gateway device, the mobile terminal device comprising: a request unit configured to perform a request for establishing only one Packet Data Network (PDN) connection which provides connectivity to a PDN associated with an access point name (APN), the PDN connection being used only for a communication between the external gateway device and a plurality of information terminal devices which includes said at least one information terminal device; a reception unit configured to receive the APN, an evolved packet system (EPS) bearer ID, and an address block, the address block being allocated by the external gateway device to the PDN connection established by the request unit, and the APN and the EPS bearer ID being allocated to the PDN connection; and an allocation unit configured to allocate an IP address generated from the address block to the at least one information terminal device, and transfer, based on the EPS bearer ID, user data as a router from the at least one information terminal device to the PDN associated with the APN via the PDN connection, wherein the mobile terminal device is connected to the at least one information terminal device.

**2**. The mobile terminal device according to claim **1**, wherein in a case that establishment of the one PDN connection is requested, the mobile terminal device is configured to notify the external gateway device of an address type of the address block for allocating the address block to the PDN connection.

**3**. The mobile terminal device according to claim **2**, wherein the address type is specified as an IPv4 type and an IPv6 type.

**4**. The mobile terminal device according to claim **1**, wherein the address block to be acquired is an IPv6 prefix.

**5**. The mobile terminal device according to claim **4**, wherein the IPv6 prefix is less than an upper-order 64 bits.

**6**. The mobile terminal device according to claim **1**, wherein the mobile terminal device is configured to request, to the external gateway device, an IPv6 prefix to be allocated to the PDN connection by using a DHCPv6.

**7**. An external gateway device in a mobile communication system comprising at least one information terminal device, a mobile terminal device, and the external gateway device, the external gateway device comprising: an establishment unit configured to establish only one Packet Data Network (PDN) connection by a request, from the mobile terminal device, for establishing the PDN connection which provides connectivity to a PDN associated with an access point name (APN), the PDN connection being used only for a communication between the external gateway device and a plurality of information terminal devices which includes said at least one information terminal device, and the mobile terminal device being connected to the at least one information terminal device; an allocation unit configured to allocate an address block to the PDN connection, and notify the mobile terminal device of the address block; an establishment unit configured to establish a connection with the at least one information terminal device via the PDN connection; and a reception unit configured to receive user data transferred by the mobile terminal device from the at least one information terminal device via the PDN connection based on an evolved packet system (EPS) bearer ID transmitted to the mobile terminal device, the APN and the EPS bearer ID being allocated to the PDN connection.

**8**. The external gateway device according to claim **7**, wherein the address block is an IPv6 prefix.

**9**. The external gateway device according to claim **8**, wherein the IPv6 prefix is less than an upper-order 64 bits.

**10**. The external gateway device according to claim **7**, wherein in a case that a request for allocating the IPv6 prefix to the PDN connection is received from the mobile terminal device by using a DHCPv6, the external gateway device is configured to allocate, to the mobile terminal device, the IPv6 prefix for the PDN connection, and notify the mobile terminal device of the IPv6 prefix.

**11**. A mobile communication system comprising: at least one information terminal device; a mobile terminal device connected to the at least one information terminal device; and an external gateway device, wherein the mobile terminal device is configured to perform a request for establishing only one Packet Data Network (PDN) connection which provides connectivity to a PDN associated with an access point name (APN), the PDN connection being used only for a communication between the external gateway device and a plurality of information terminal devices which includes said at least one information terminal device, the external gateway device is configured to allocate an address block to the PDN connection established by the request, and send the address block to the mobile terminal device, and the mobile terminal device is configured to: receive the APN, an evolved packet system

(EPS) bearer ID, and the address block, the APN and the EPS bearer ID being allocated to the PDN connection, allocate an IP address generated from the obtained address block to the information terminal device, and transfer, based on the EPS bearer ID, user data as a router from the at least one information terminal device to the PDN associated with the APN via the PDN connection.

**12**. A communication method executed by a mobile terminal device in a mobile communication system comprising at least one information terminal device, the mobile terminal device, and an external gateway device, the communication method comprising: requesting establishment of only one Packet Data Network (PDN) connection which provides connectivity to a PDN associated with an access point name (APN), the PDN connection being used only for a communication between the external gateway device and a plurality of information terminal devices which includes said at least one information terminal device, the mobile terminal device being connected to the at least one information terminal device; receiving the APN, an evolved packet system (EPS) bearer ID, and an address block, the address block being allocated by the external gateway device to the PDN connection established, and the APN and the EPS bearer ID being allocated to the PDN connection; and allocating an IP address generated from the address block to the information terminal device, and forwarding, based on the EPS bearer ID, user data as a router from the at least one information terminal device to the PDN associated with the APN via the PDN connection.

**13**. A communication method executed by an external gateway device in a mobile communication system comprising at least one information terminal device, a mobile terminal device, and the external gateway device, the communication method comprising: receiving from the mobile terminal device, a request for establishing only one Packet Data Network (PDN) connection which provides connectivity to a PDN associated with an access point name (APN), the PDN connection being used only for a communication between the external gateway device and a plurality of information terminal devices which includes said at least one information terminal device, and the mobile terminal device being connected to the at least one information terminal device; allocating an address block to the PDN connection established, and sending the address block to the mobile terminal device; establishing connection with the at least one information terminal device via the PDN connection; and receiving user data transferred by the mobile terminal device from the at least one information terminal device via the PDN connection based on an evolved packet system (EPS) bearer ID transmitted to the mobile terminal device, the APN and the EPS bearer ID being allocated to the PDN connection.

**14**. A mobile terminal device in a mobile communication system comprising at least one information terminal device, the mobile terminal device, and an external gateway device, the mobile terminal device comprising: a request unit configured to perform a request for establishing only one Packet Data Network (PDN) connection which provides connectivity to a PDN associated with an access point name (APN), the PDN connection being used only for a communication between the external gateway device and a plurality of information terminal devices which includes said at least one information terminal device; a reception unit configured to receive the APN, an evolved packet system (EPS) bearer ID, and an address block, the address block being allocated by the external gateway device to the PDN connection established by the request unit, and the APN and the EPS bearer ID being allocated to the PDN connection; and an allocation unit configured to allocate an IPv6 prefix generated from the address block to the at least one information terminal device, and transfer, based on the EPS bearer ID, user data as a router from the at least one information terminal device to the PDN associated with the APN via the PDN connection, wherein the mobile terminal device is connected to the at least one information terminal device.

* * * * *